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# AMERICAN WATER WORKS ASSOCIATION

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## CONTENTS

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VOL. 22 FEBRUARY, 1930 No. 2

## DIESEL ENGINES FOR WATER WORKS[1]

By R. L. Baldwin[2]

The selection of the type of prime mover or power to use in waterworks service is important. It affects the economy of operation and the reliability of service. In the older pumping stations steam was used and it came to be regarded as the most reliable type of equipment. In the last quarter century the electric power plant has been developed and transmission lines have been constructed so that electric power is competing, and, in a large number of the smaller stations and some large stations, is displacing steam driven units. Many of the smaller pumping stations have used gasoline engines to operate their pumps and these engines have performed this service well. Gasoline engines of the automobile type with push button type starters are being used as emergency units in connection with motor driven stations where there is any possibility of interruption of power service. The Diesel engine is much more efficient than the gasoline engine and than almost any type of steam or motor drive.

The Diesel engine was invented by Rudolf Diesel in Germany in 1893. His patents covered the entire elimination of all ignition devices, electric spark, hot tube or plates as well as carburetors or mixing devices. These engines came into use in Europe several

[1] Presented before the Missouri Valley Section meeting, November 7, 1929.

[2] Burns and McDonnell Engineering Company, Kansas City, Kans.

years before much effort was made towards their adoption in America. The first production of any magnitude here was in 1904. Of 11 Diesels of more than 100 h.p. which were built and installed in 1904, 9 were still in operation a year ago and probably are yet. Prior to 1914 there was only one licensed builder of Diesel engines in this country. At that time the original patents expired and now there are a number of manufacturers who are building these engines. Twelve of the leading builders have recently organized the "Diesel Engine Manufacturing Association."

For marine work, particularly on tugs, work boats, and crafts intermediate between small pleasure launches and large ocean-going ships, the use of Diesel engines is rapidly increasing. New applications are constantly being made. During this year a 200 h.p. radial air

TABLE 1

*Distribution of uses of oil engines*

| INDUSTRY | HORSEPOWER | PERCENT |
|---|---|---|
| Central Stations | 1,236,533 | 20.5 |
| Industrial Stationary | 1,198,425 | 19.8 |
| Industrial Portable | 361,756 | 5.9 |
| Marine Propulsion | 1,441,187 | 23.7 |
| Pumping | 1,319,659 | 21.8 |
| Refrigeration | 359,881 | 5.7 |
| Other Uses | 131,252 | 2.6 |
| | 6,048,693 | 100.0 |

cooled Diesel manufactured by the Packard Motor Car Company was used in an airplane on a successful cross country flight, and in Germany an 800 h.p. Diesel engine has been used in an airplane. These engines are used for drainage and irrigation service, demonstrating two important advantages of oil engines, namely the ability to start from cold at a few minutes notice and the ability to operate for long periods of time with low fuel cost. That such engines may be operated for long periods with no ill effects is demonstrated. At Sterling, Kansas, an engine was put in service and its first long run was 103 days followed by a 6-day shut down for inspection. Then it was run 129 days with only a 2-day shut down. Oil Engine Power of October, 1929, describes an installation which has a non-stop record of 6,537 hours or over 272 days and this was the third long run, the first being 135 days and the second 211 days.

The use of oil engines in different industries is given in table 1. These data are taken from the 1929 issue of the "Oil Engine Power Plant Handbook."

Approximately one-fourth of the horsepower of Diesel engines sold in this country is in pumping service used for either water, sewage, or oil. Of course, the large portion of this capacity is in oil pipe line service, but the engines have demonstrated their economy and reliability in that service and deserve serious consideration wherever the waterworks profession has a power problem.

In a recent paper entitled "The Selection of Pumping Station Equipment" presented at the Toronto Convention by A. P. Pigman, Engineer for the American Waterworks and Electric Company, operators of numerous large waterworks systems, the different kinds of power are considered. The size of plant is considered in terms of horse power capacity and the field of each roughly blocked out. The writer is quoted as follows:

"1. When a new plant is to be built for single pumpage at nearly uniform rate a steam plant will usually be the most economical, provided the load is sufficient to call for turbines of more than 1500 horse power capacity.

"2. For similar plants with loads averaging less than 250 horse power the electric plant will ordinarily be most economical, but, if the power rates are high, the Diesel plant will be better.

"3. In between these the field is highly competitive for the three types of equipment with the Diesel having ordinarily a slight advantage, which tends to give way to the steam plant in the upper range and to the electric plant in the lower range."

The "more than 1500 h.p." plant referred to above corresponds to a pumpage rate of about 25 m.g.d. against 300 foot head and the "less than 250 h.p." plant corresponds to a pumpage rate of about 2.5 m.g.d. against 300 foot head.

## EXAMPLES OF DIESEL ENGINE INSTALLATION

In a paper presented before the New England Water Works Association recently, A. D. Couch, Mechanical Engineer of the Community Water Service Company, New York City, describes their "Experience With Diesel Engines in Waterworks Plants." He describes a pumping plant at Pocantico Hills, New York, which contained three 125 h.p. boilers and two horizontal duplex triple expansion pumps handling about 3 m.g.d. He gives data summarized in table 2.

This shows very clearly the comparison in this case and, while maintenance in the early years is naturally low, it would be impossible for it to offset such a difference in annual charges. This was for an installation costing $43,500, and it is interesting to note that it would require an electric rate of $1\frac{1}{8}$ cents per k.w.h. to equal this operating cost.

These references show there is a tendency for waterworks operators to give more thought to obtaining the most economical operation and to throw open the door to a wider use of the Diesel engine for driving pumping equipment.

A small city has an average pumpage of less than 500,000 gallons per day against 200 feet head from a river to large settling basin. The old pumping equipment consisted of a steam driven compound

TABLE 2

*Operating data for Pocantico Hills, N. Y.*

| TYPE OF PLANT | ANNUAL OPERATING COST PLUS 15 PER CENT FIXED CHARGES | REMARKS |
|---|---|---|
| Steam | $28,944 | 5-year average not including fixed charges |
| Electric | 29,825 | Estimate based on actual rate 2 cents per k.w.h. |
| Diesel | 23,255 | Estimate before installation |
| Diesel | 20,248 | Actual cost first year's operation |

duplex pump and a motor driven centrifugal pump. The motor driven pump due to high rates was held as a reserve unit. The officials considered and have since purchased an oil engine driven centrifugal pump driving the pump through a speed changing gear.

The operating cost of the old plant was as follows:

| | |
|---|---|
| Pump station operation | $3,650.50 |
| Coal | 3,521.38 |
| Total | $7,271.88 |

The estimated cost of operation with Diesel driven unit follows:

| | |
|---|---|
| Fuel and lubrication | $960.00 |
| Maintenance | 240.00 |
| Operating labor | 1,200.00 |
| Depreciation, interest and insurance | 1,800.00 |
| Total | $4,200.00 |

The cost of this improvement was $15,000 and even with all fixed charges included shows a remarkable saving. However, if the power company had been more aggressive they could have made a rate that might have secured this business. Where long hour service can be given, that is, where pumps can be made small and operated 24 hours a day instead of intermittently, electric power has a much better chance, since the connected load charge is a minimum due to the fact that smaller size units can be used. This should always be kept in mind when such a problem is being considered.

Another comparison worked out for a 1000 g.p.m. installation against 200 foot head, assuming operation 12 hours per day gave the following figures:

First, a Diesel driven triplex pump was taken. Engine size required 75 h.p.; cost of equipment installed, including building and auxiliaries, $18,500; fuel oil cost taken at 6 cents per gallon.

Second, a motor driven triplex pump to meet the same requirements. Cost of equipment installed, including building and substation, $10,000. Power cost average 2 cents per k.w.h.

Third, a motor driven centrifugal pump for the same service, cost of equipment installed complete, including building and substation, $7,500. Power cost 2 cents per k.w.h.

The comparative total annual cost, including fixed charges, was as follows:

| | |
|---|---|
| Diesel driven triplex pump | $7,000 |
| Motor driven triplex pump | 9,760 |
| Motor driven centrifugal pump | 7,590 |

Even in this small unit it is necessary for electric power cost to be below 2 cents per k.w.h. to compete with the Diesel engine driven unit. For the motor driven triplex pumping installation the rate would have to be 0.9 cent per k.h.w. and for the motor driven centrifugal pumping installation it would have to be 1.8 cents per k.w.h. to equal the Diesel driven unit.

The question of motive power to be used is generally one of economics. The user selects that type which he expects will give either lower first cost, better service, or cheaper operating cost. The first cost of a Diesel engine driven plant in most cases would be as high and in many cases higher than other types of plant which could be installed. Other plants can usually be designed to give as good service. Therefore, if we are to find any advantage in the Diesel

plant, we must look for it in the lower operating cost and this must be enough to offset increased interest and depreciation charges if the first cost is greater.

## EFFICIENCY OF DIESEL ENGINES

The thermal efficiency of the average steam plant will be from 10 to 15 percent and even the very highest type steam plant of most modern design and very large capacity will not exceed 28 percent. The thermal efficiency of the Diesel engine averages about 32 percent

TABLE 3

*Comparison of fuel B.T.U. per K.W.H. generated*

| TYPE OF PRIME MOVER | FULL LOAD | ONE-HALF LOAD | QUARTER LOAD |
|---|---|---|---|
| 1. Single cylinder steam engine 100 pounds steam pressure non-condensing | 64,000 | 78,000 | 123,000 |
| 2. Compound steam engine, 150 pounds steam pressure 26-inch vacuum | 37,000 | 45,000 | 66,000 |
| 3. Steam Turbine, 150 pounds steam pressure, 28-inch vacuum | 28,000 | 36,000 | 50,000 |
| 4. Large steam turbine, 400 pounds steam pressure, 250° superheat, 28 inches vacuum | 13,000 | 13,300 | 14,000 |
| 5. Diesel Engine | 11,000 | 13,000 | 20,000 |

and this does not vary greatly from the smallest to the largest units, or from half to full load.

Efficiency of steam driven pumping units is generally expressed in foot pounds of work done per thousand pounds of steam used, but can also be expressed in foot pounds of work done per million B.t.u., which measure can be applied to the Diesel driven unit as well.

A large oil engine will deliver a brake horse power hour at full load on a fuel consumption of 7500 to 8000 B.t.u. Even Diesel engines as small as 25 h.p. will produce a brake horse power hour on 9500 B.t.u.

A small Diesel engine driving a pump having an efficiency of 80 percent would have a duty of 166,000,000 foot pounds per million B.t.u.

A crank and flywheel steam pumping engine of an equivalent size

would have a duty of approximately 75,000,000 foot pounds per million B.t.u.

The duty of a triple expansion steam pumping engine of 20 to 30 million gallons capacity per day will be about 170,000,000 foot pounds per million B.t.u.

A centrifugal pump driven by a steam turbine using high pressure steam and superheat will have a duty of about 180,000,000 foot pounds per million B.t.u.

The larger size Diesel engines with large pumps can attain a duty in excess of 200,000,000 foot pounds per million B.t.u.

In the article by Mr. Couch already referred to, the 338 h.p. engine geared to a centrifugal pump with a capacity of three million gallons per day had an actual duty test of 354,400,000 foot pounds per 100 pounds of fuel consumed, which, if oil is taken as having 18,000 B.t.u. per pound of fuel oil, gives a duty of 196,000,000 foot pounds per million B.t.u.

A comparison of the Diesel engine with a few of the common types of steam driven prime movers shows the remarkable fuel saving possible. Table 3 compares these on the basis of the B.t.u. in fuel per k.w.h. generated.

The guarantees used for a large steam turbine, Item 4, are for a 25,000 k.v.a. unit or approximately ten times the capacity of the size used for the Diesel engine.

### ADDITIONAL INSTALLATIONS

Many installations are in service where the waterworks is operated in conjunction with an electric light and power service. Such installations exist at Ponca City, Oklahoma; Sterling, Kansas; Carthage, Missouri; Neodesha, Kansas; Ossawatomie, Kansas; Sioux Falls, South Dakota; the Lankershim plant on the Los Angeles water supply, and many others. The Sterling, Kansas, plant saved $800.00 per month in fuel over their old steam plant. The installation in Sioux Falls, South Dakota, has separate units for electric lighting service and for waterworks service. Their pumpage cost for the month of August, 1929, is shown in table 4.

The water pumped was 137,610,000 gallons, against average pressure of 75 pounds. The average cost was $9.50 per million gallons. The average for a year may be more than this if maintenance items are added. A comparison of this cost with other methods of pumping is interesting.

At Springfield, Illinois, where the pumpage rate is about double that at Sioux Falls and the average pressure 85 pounds, the cost per million is $17.60. If the pressure were 75 pounds, it would be about $16.00 per million. Pumpage is mainly by means of a vertical triple expansion pumping engine.

At Kansas City, Missouri, the Turkey Creek pumping station has an average pumpage of 45 m.g.d., uses boiler fuel oil costing $1.64 per barrel and the cost is 0.054 per million per foot of lift which would be $9.44 per million at 75 pounds pressure. The East Bottoms pumping station is motor driven and uses power costing about 1½ cents per k.w.h. The average pumping rate is about 10 m.g.d. Pumping cost is 0.098 per million per foot of lift which would be $16.90 per million at 75 pounds pressure.

TABLE 4

*Pumpage Costs at Sioux Falls, August, 1929*

| | | |
|---|---|---|
| 8,418 gallons fuel oil | @ 0.0466 | $392.28 |
| 49 gallons lubricating oil | @ 0.528 | 25.87 |
| 4 gallons compressor oil | @ 0.626 | 2.50 |
| 7 gallons kerosene | @ 0.134 | .94 |
| 50 pounds wiping rags | @ 0.1575 | 7.78 |
| Payroll | | 874.00 |
| Total operating cost | | $1,303.37 |

St. Louis, Missouri, high service pumping station, with steam turbine driven centrifugal pumps and pumping an average of 115 m.g.d., using coal for fuel, has a cost of 0.035 per million per foot of lift which would be $6.04 per million at 75 pounds pressure.

These costs compare very favorably when it is considered that the stations have intentionally been selected having much larger capacity.

Where operation is only for pumping as at Kearney, Nebraska, where power is generated to pump a scattered well system and then to pump the water from a central suction well into the distribution system at about 45 pounds pressure, the operating cost is about $14.00 per million gallons. The old steam plant operated at approximately 30 pounds pressure with a cost of $32.50 per million, which would be almost $50.00 per million gallons at the pressure now carried. The pumping cost is less than half what it was while the pressure has been increased by 50 percent.

The cost of pumping at Trenton, Missouri, where motor driven pumps are used and pumpage rate is about $\frac{3}{4}$ m.g.d. is \$50.00 per million gallons.

The Manhattan and Lomita plants of the Los Angeles system are true waterworks plants. The first has a 740 h.p. Diesel direct connected to a 650 k.v.a. generator and the second has two units of that size. Power is generated and distributed to wells which are pumped with suitable equipment. When these plants were built it was because of a drouth which also made dependence on hydroelectric power questionable.

Kenner, Louisiana, operates a combination light and pumping plant with two 80 h.p. engines driving generators and connected to a centrifugal pump through a reduction gear and a clutch so that the pump may be disconnected when desired.

Santa Cruz, California, uses two 360 h.p. engines direct connected to 300 k.v.a. generators which supply current for pumping. This plant has shown an operating cost of about \$7.00 per million gallons against a pressure of 100 pounds with fuel at 4 cents and lubricating oil at 43 cents.

Fayetteville, Arkansas, has a 150 h.p. Diesel driving a triplex pump and a 240 h.p. Diesel engine driving a 12-inch by 18-inch outside center packed power pump. The fuel cost is about $1\frac{1}{4}$ cents per thousand gallons pumped, using $6\frac{3}{8}$ cents fuel oil and 55 cents lubricating oil. Pressure is 285 pounds.

Corsicana, Texas, has a Diesel engine driven centrifugal pump and La Porte, Indiana, has a similar installation. Jackson, Tennessee, has a Diesel engine driven generating plant for producing power for low service pumps. Cleburne, Texas, has a Diesel engine compressor used to supply air for a system of air lift wells. It also operates a generator which is used to drive motor driven centrifugals for high service pumping.

This collection of miscellaneous data in regard to various installations indicates that the Diesel does have some advantages which merit consideration in your power problems.

# THE TWO-MAIN SYSTEM OF WATER DISTRIBUTION[1]

By J. B. Eddy[2]

The City of Chicago has adopted a definite policy regarding the use of the two-main system of water distribution. While not used exclusively for all new installations, its advantages are kept in mind and whenever the benefits to be derived warrant it, the two main system is used. In car line streets, wide boulevards, newly widened traffic arteries and in streets 80 feet wide, with fronting lots, two mains are laid. The first street in which two mains were laid in place of one was a "down-town" business street. The facts concerning this installation may be of interest.

During the years from 1907 to 1912 inclusive, pitometer surveys were in progress in and adjacent to the central commercial and business section (known as the Loop district) of Chicago. Elimination of underground leakage was a part of this work, special attention being given to streets about to be paved. In this section of the city many services had been abandoned where large buildings occupying a number of lots replaced a number of smaller buildings. These abandoned service pipes, of lead, were often battered shut where cut near the curb, many opened up from the effect of pressure, and sand washing quickly enlarged the opening. The result was usually an underground unobserved leak—growing as time went on until many were discharging the full capacity of the service. This section of Chicago has a sandy subsoil over which usually were placed, as the street grades were raised, cinders or other fill, making easy the escape of underground water to the sewer. Under such conditions it was necessary that the water system be thoroughly overhauled prior to repaving.

The 6-inch main in Randolph St., La Salle St. to State St. (three blocks), was tested for underground leakage in 1910 previous to repaving. The tests were made at night because of the density of

[1] Presented before the Toronto Convention, June 27, 1929.

[2] Engineer, Water Pipe Extension, Bureau of Engineering, Department of Public Works, Chicago, Ill.

daylight traffic and the inconvenience to the public which would result from a shutoff made during the daytime. Underground leakage amounting to approximately 200,000 g.p.d. was measured.

This 6-inch pipe was laid about 1855 as a part of the original cast iron system. Later, filling placed in this street gave the pipe a cover of about ten feet. Street-car tracks were laid over the 6-inch pipe, the location of the main at State and Randolph Streets being about


FIG. 1. TRAFFIC IN RANDOLPH ST. LOOKING WEST FROM STATE ST.

one foot south of the center line of the street. After a comprehensive study had been made it was decided to replace the old 6-inch with two new mains, one 12-inch to extend from State St. to La Salle St. adjacent to the north curb, and one 8-inch to be laid adjacent to the south curb in blocks requiring services.

The reasons for this decision were as follows:

1. It would be very costly to locate and stop the underground leakage.

2. Traffic would have to be diverted to other streets while repairs

were being made, which would greatly inconvenience the business houses on this street and the public generally.

3. Additional supply, both for fire and commercial use, was necessary.

4. Service pipe stubs not in use could be abandoned.

5. Live services could be retapped to the new mains, thus eliminating all piping beneath the car tracks (except at cross streets), making less service pipe to be maintained and reducing the electrolysis, known to be active in this street.

6. Future large service pipes for fire and commercial use could be installed at greatly reduced cost.

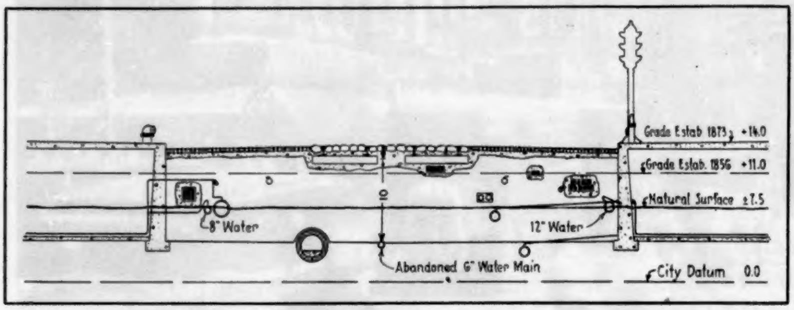


FIG. 2. CROSS-SECTION OF RANDOLPH ST., WEST LINE OF STATE ST., SHOWING ABANDONED 6-INCH MAIN WITH EXISTING 12- AND 8-INCH MAINS AND UTILITIES

7. The mains near the curb lines could be maintained with little inconvenience to the public and at less cost than the old main beneath the street-car tracks.

8. No main would be laid on the south side of the street between La Salle St. and Clark St. because of no service requirement. Fire protection in this block would be furnished from the 12-inch main.

The factors given greatest weight in the conclusion reached were:

1. Public convenience
2. Future maintenance cost
3. Additional supply
4. Elimination of underground leakage
5. Electrolysis mitigation

The 12- and 8-inch mains were installed in 1910 and this marked the beginning of the use of the two main system in Chicago.

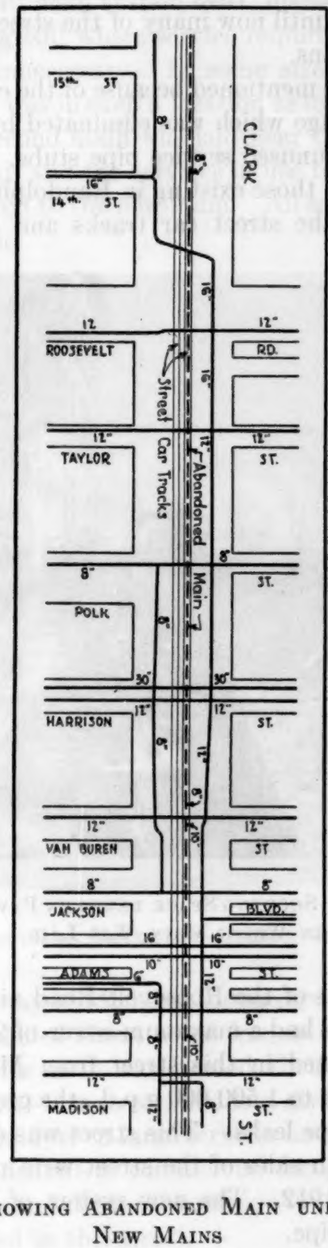


FIG. 3. CLARK ST., SHOWING ABANDONED MAIN UNDER CAR TRACK, AND NEW MAINS

Since this work was done, similar investigations have been made in other loop streets until now many of the streets in the downtown section have two mains.

Clark St. should be mentioned because of the considerable amount of underground leakage which was eliminated by the abandonment of the old main and unused service pipe stubs. Conditions in this street were similar to those existing in Randolph St. The old main was deep, beneath the street car tracks and inadequate in size.

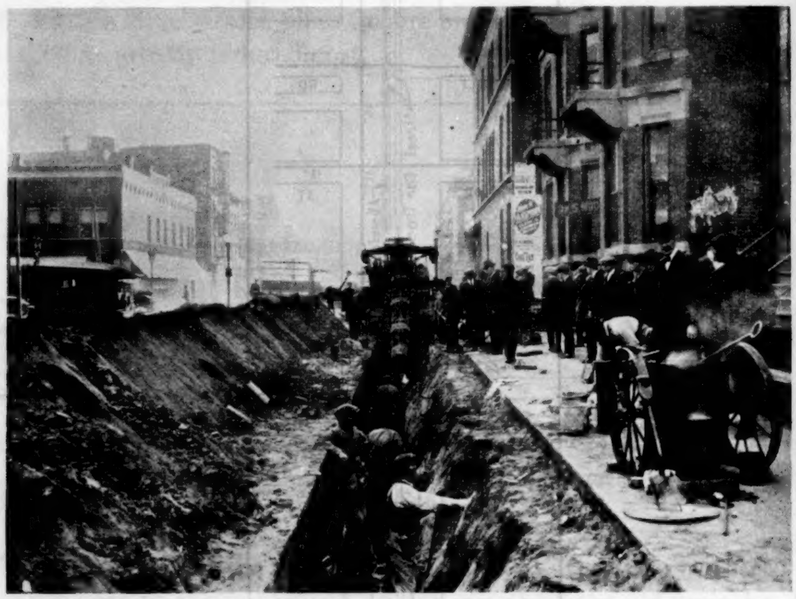

FIG. 4. MICHIGAN AVE.—SHOWING SPACE BETWEEN PAVEMENT AND SIDEWALK IN WHICH MAIN WAS LAID

Under the approaches of the Roosevelt Road viaduct the old main and service pipe stubs had a maximum cover of 20 feet. The measured leakage eliminated in this street from Madison St. to 15th St. 6,600 feet, amount to 1,500,000 g.p.d., the greatest part of which was due to service pipe leaks. This street was double mained only where services to both sides of the street were necessary, the work being completed in 1912. The new system of mains consisted of 16-, 12- and 8-inch pipe.

Water mains in the Loop are not laid in the sidewalk space, because this space is usually occupied for storage and other purposes.

Variations of the two main system exist, mains being laid in alleys, only one main being laid where service requirements are such as to make two mains unnecessary. In some streets having street-car tracks the old main was in such a location as to be readily accessible. In such streets a second main was laid near the opposite curb, the old main overhauled, and the services in use to the opposite side of the street reconnected to the new main. All service pipe stubs were shut off at the main.

FIG. 5. DEPRESSION IN PAVEMENT CAUSED BY CROSS TRENCHES

In 1922 the roadway of Michigan Boulevard from Roosevelt Road to 33rd St. was widened about seven feet on either side and paved. The old 6-inch water main was located about ten feet west of the center line of this 100-foot street, and had given much trouble when repairs were made and when large services had to be installed due to a change from residential to commercial occupation because of the danger to workmen and the inconvenience to motorists. Additional capacity was needed in this street.

It was decided to abandon the old 6-inch and install two 8-inch mains, one on either side of the Boulevard. Trenches were excavated

by digging machines, excepting street intersections which were dug by hand. Each main was laid as near the new curb line as possible. It was necessary to cut the sidewalk for 10,560 feet of this improvement. In the remainder there was a 7-foot parking space in which the pipe was laid. The amount of pipe laid was 23,720 feet and the time required for the work was about four weeks.

Many old service pipe stubs were abandoned. All live services were reconnected. The cost of this work was $2.95 per foot, the material costing $1.60 per foot.

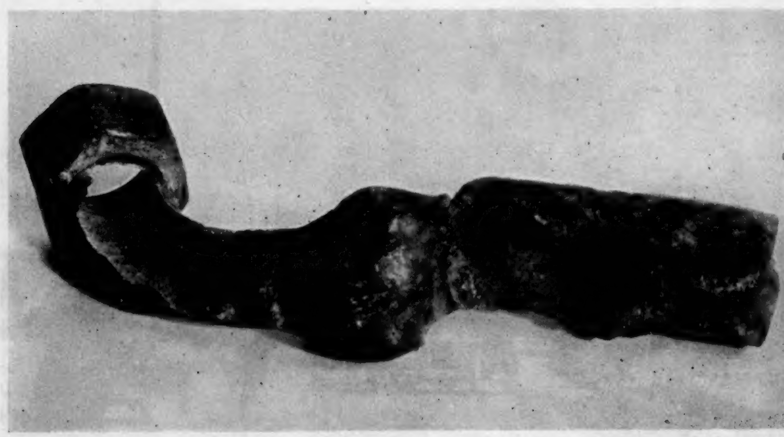

Fig. 6. Mackinaw Ave., 62 Feet South of 89th St. Defective Wiped Joint and Coupling

Whether or not the two main system is used in Chicago is not always determined by first cost. It is installed in business streets, car line streets and boulevards because it has been shown by experience that after installation in such streets the two main system causes less inconvenience to the public and is less costly to maintain than one main with long services.

In all residence streets of less than 80 feet in width, except State roads, an estimate of cost is made to determine which system shall be installed. However, there are many factors which should be considered in addition to first cost when deciding whether or not to use two mains.

Usually the street pavement is laid a very short time after the water main and service stubs have been installed, and for this reason

pressure is being exerted to have all excavated material other than sand or gravel hauled away and sand used for backfill, so that the pavement can be laid immediately following the completion of underground utility work. This provision has been enforced a number of

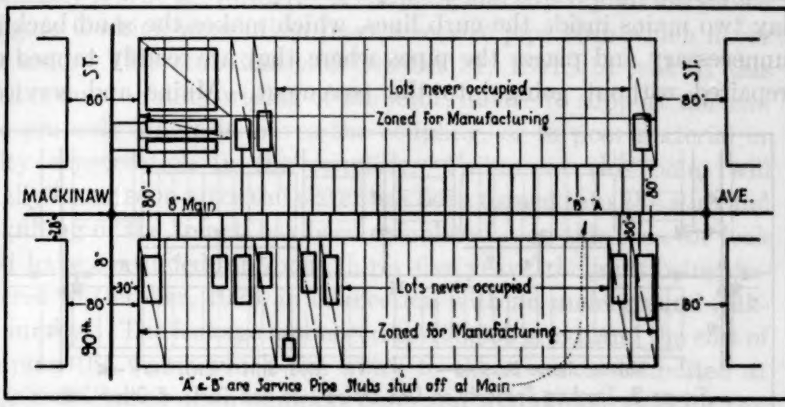


FIG. 7. MACKINAW AVE., 89TH TO 90TH STS. SHOWING MAIN, LIVE SERVICES AND STUBS

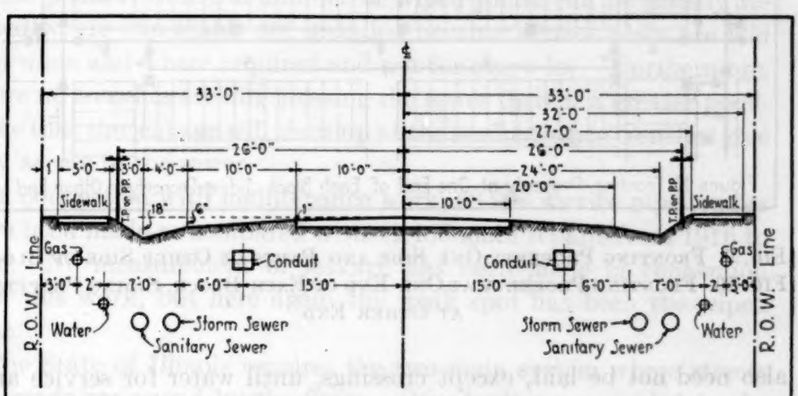


FIG. 8. EXAMPLE OF TWO-MAIN SYSTEMS SPECIFIED BY STATE OF ILLINOIS FOR STREETS PAVED BY THE STATE

times within the past few years and the cost of hauling away excavated material and hauling in sand, plus the cost of one main and long services, greatly exceeds the cost of two mains back of the curb lines. Of course, it is necessary that traffic arteries be out of service for

repaving as short a time as possible, and sand backfill aids greatly in cutting down the time of making the improvement and insures that the new pavement will not settle over newly made trenches. It does not assure that the new pavement will not be cut to make repairs, and, therefore, when no main has previously been laid it is better to lay two mains inside the curb lines, which makes the sand backfill unnecessary and places the pipes where they are readily tapped or repaired without going into the pavement. Mains and services

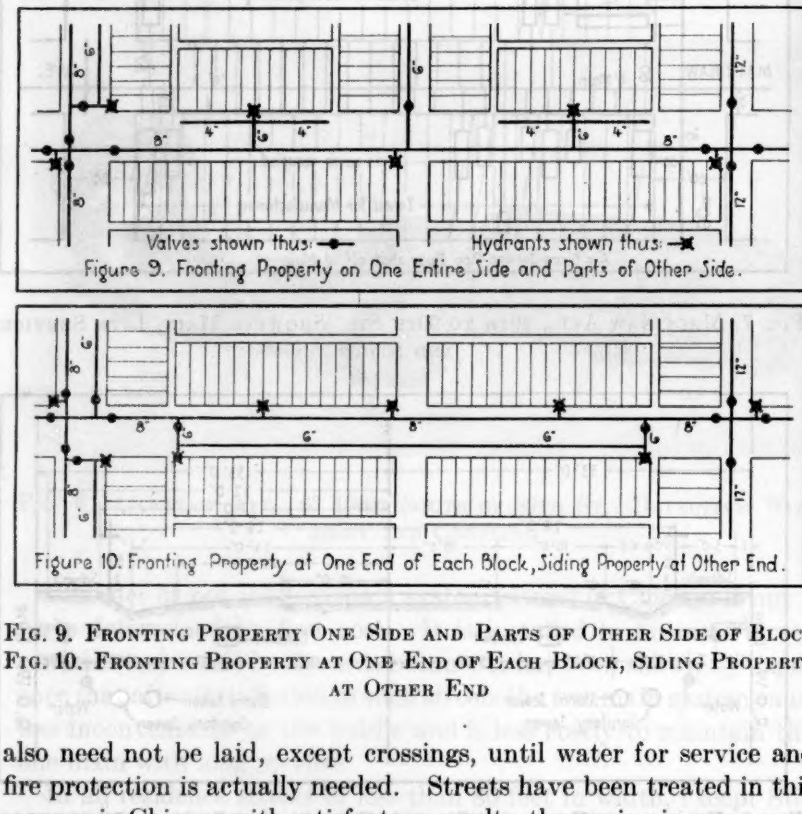


FIG. 9. FRONTING PROPERTY ONE SIDE AND PARTS OF OTHER SIDE OF BLOCK
FIG. 10. FRONTING PROPERTY AT ONE END OF EACH BLOCK, SIDING PROPERTY AT OTHER END

also need not be laid, except crossings, until water for service and fire protection is actually needed. Streets have been treated in this manner in Chicago with satisfactory results, the paving in some cases having been down for five or six years before water was required in the street.

In connection with the overhauling of mains and services, prior to paving, it has been found that the lead service pipe is a greater source of underground leakage than the cast iron main. From 1916 to date, 966 service pipe leaks have been repaired which showed a

measured leakage of 5,336,000 g.p.d. During the same period 429 main leaks have been repaired which gave a measured leakage of 3,590,000 g.p.d. The service pipe leaks are usually at the wiped joint either at the coupling to the tap or at the stopcock. More frequently it is at the former. A coupling and wiped joint are shown in figure 6 which were taken from a service pipe stub which never was used. This stub was laid October 31, 1891. A leak at this point is due to faulty wiping of the joint, failure to support the lead pipe properly where it leaves the coupling, or to poor material or faulty construction in the coupling. Failure at this point will usually occur soon after the water has been turned into the stub and backfilling of the trench has been completed. In this case the leak must have continued for about thirty-five years, the joint being discovered in October, 1926, in connection with an underground leakage survey. The leakage amounted to 100,000 g.p.d. and the cost of pumping the water which ran away to the sewer is estimated at $38,000.00 (based upon pumping cost) and would have paid for two mains 8-inches in diameter in this 80-foot street for 6,000 feet of frontage. Two joints out of a total of 40 failed in this block.

The point is that the number of wiped joints can be greatly reduced where two mains are installed because service pipes are laid *only* when and where required and not for every lot. Furthermore, where no trenches are dug crossing the sewer there is a greater possibility that the leakage will show up at the surface, since trenches give easy access to the sewer.

In connection with maintenance work, 68,998 service pipe repairs have been made as compared with 41,459 main repairs from 1916 to date. No measurement of leakage has been made in connection with this work, but here again the weak spot has been the wiped joint.

The State of Illinois requires the two main system where streets and roads are paved by the State. Standards are provided in the State specifications for arrangement of pipes, sewers and conduits for rights of way varying from 50 to 100 feet, one of which is shown in figure 8. Provision is made that all pipes, sewers and poles shall be placed outside of a 40 foot strip which centers on the center line of the right of way. The conduits are located so that they clear a 20 foot pavement, but lie under a 40 foot pavement.

In a number of streets that were being repaved, it was found economical to abandon the old main and lay two new ones. The old main in each case was obsolescent, badly corroded by electrolysis,

inaccessible, or it was known that the cost of digging it up to salvage would exceed the value of the pipe. Old mains where accessible and in good physical condition are always overhauled before a street is paved, leakage being located and stopped and abandoned services closed off at the main.

Many variations of the two main system may be used. A street may have solid frontage on one side and partial frontage on the other, in which case the plan shown in figures 9 and 10 may be used.

In some sections of Chicago the two main system has been used almost exclusively. In one quarter section, for example, only three blocks have the single main and long services and these mains were laid before the two main system was considered. The mains are 8 and 6 inches in diameter and are laid 10 feet from the street lines. Fire hydrants are connected to both mains. State St. has three mains—one 24-inch feeder main and two service mains 6- and 8-inches in diameter.

Another quarter section has all streets double mained except 83rd St. and 85th St. which have but a few fronting lots. This quarter section has 998 fronting lots of varying width, the greater number being 25 feet. Ninety-three services have been installed, and since this quarter section is zoned for apartment buildings it is estimated that there will be not more than 250 services required, most of which will be of cast iron. None of these need be installed before the building to be served is under construction and none will ever need to be laid beneath the pavement. In this quarter section, the saving in the first cost of services alone is a large item and the additional saving that will result from the fact that there will be no dead services to maintain or cut off is also of considerable importance.

Experience in Chicago with the two main system has been most satisfactory and demonstrates that this system is more economical under the conditions where used than would be the single main system. The saving in initial cost of service pipe, the lower maintenance cost, the additional capacity, the better fire protection, the reduction of electrolysis, all contribute to economy.

## *DISCUSSION*

WM. W. BRUSH:[3] Does it cost less for a two-main system than a one-main system, including the cost of the service pipes?

[3] Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

Mr. Eddy:[2] In the particular quarter section I showed on the map it did cost less with the two mains as shown, by about $85,000, than it would have cost to lay the one main with the service pipes. That street is 100 feet wide.

Mr. Brush:[3] If you are not installing the service pipes would you then be inclined to put in two mains?

Mr. Eddy:[2] Where there are no buildings, and where the street is 80 feet or more in width, it would be necessary for the sub-division owner to deposit money with the city of Chicago, to cover the cost of the pipe, but if there were a sufficient number of services to pay 15 percent revenue then the mains would be laid on both sides of the street.

Mr. Brush:[3] In some instances you put the main between the building and the curb, and in other instances you put it alongside of the curb—what is that governed by?

Mr. Eddy:[2] It is governed by the occupancy of the territory. In all downtown districts, where the territory is very valuable, the downstairs part of the building is used for barber shops and storage, and that makes it necessary to lay our pipes near the curb, because the space next to the building is occupied. In all cases we lay the pipe as near the curb as possible.

Mr. Brush:[3] In a street where that space is not occupied do you try to determine what is likely to be the future occupancy, and whether you should go under the street or under the sidewalk?

Mr. Eddy:[2] No.

Mr. Brush:[3] We have had the question up on several occasions, as to whether to put in two mains or not, and we have adopted the policy followed by Chicago to some extent, but I do not think we have been quite as general in the use of two mains as Chicago. We do not put in any services from the mains until they are needed. We object to services that are not in use. There is not a sufficient saving to avoid the expense of cutting the pavement. We would rather cut the pavement than have an unused service. I think there will be

more and more use made of the two-main system in the future, because of the greater traffic on the streets and the demand for more convenient connections. The people are willing to pay more money to-day for freedom from annoyance by street openings, and they have more money than they had twenty years ago. No matter what the size of the community we should always consider carefully whether it would not be a better thing in some streets to put in two mains, and what is the best form of installation to use for each individual street.

Mr. Eddy has shown two or three different ways of connecting up from one side of the street to the other, and I think there is some question as to what form would be the most economical.

You might be interested in a statement I can make as to what Mr. Fenkell said as to using storage above the line of your distribution service. We have a 20,000,000 gallon reservoir that I thought a couple of years ago had outlived its usefulness.. One of our engineers suggested that it might be used for a lower service. It was an intermediate service reservoir, 43 feet higher than the level of the low service. We were finding difficulty in maintaining our pressure during the hours of high consumption. We only have a single tunnel for the Catskill water supply which is used for all three services. The reservoir has 20 feet depth of water in the morning, and is now used for low service. By the late afternoon, or early evening hours, it is down as low as about 7 feet from the bottom. That shows a use in less than 12 hours of contents for a depth of 13 feet. The result is that at times of the maximum draft we are able to draw at the rate of 30,000,000 a day, and thereby reduce the draft that otherwise would have to be taken care of by our tunnel, which is quite seriously over-burdened. There are cases where I think you would find you could utilize storage, where you have two or more levels, and where, for the time being, your trunk line capacity is not up to what you require. There is one thing in connection with lower level storage that I think we should keep in mind, and that is that our trunk main capacity should not be so small as to normally necessitate such a condition. We should not use, as a permanent plan, an expedient that is temporary.

I believe the majority of our American communities have sufficient financial resources so that there can always be a substitute for any main that might be put out of service. We are endeavoring in New York to so plan the system that any main, no matter of what size,

can be put out of service, and still we can deliver an adequate supply for domestic or fire use. Naturally, it would not be quite as large as when all mains are in service, but it should be so that the service can be sufficient to meet any anticipated demands with one main out of use. We are dependent to-day upon a single Catskill tunnel. If that tunnel should be put out of service there are nearly three million people who could only exist. They could not live with any degree of comfort until that tunnel was put back into service. That should not be, and it will take from four to five years before that situation can be corrected by the new tunnel now being built.

I doubt whether New York will ever allow such a situation to develop again, but it is a situation that now exists and is in accordance with what has been in practice in the past, i.e., to depend upon a single line, and trust that nothing will happen to the line. Nothing has happened to our Croton tunnel, which has been in use for between thirty and forty years, but we should visualize what would be the situation if some part of our system failed and try to guard against it. What I am saying about New York appliesto any system, whether large or small.

THE CHAIRMAN: One of the matters I am engaged with in Buffalo is the new sub-division work where we are putting in a double system. That is paid for by the sub-division people, and the money is refunded to them as the mains come into use. We are laying a 6-inch pipe on one side of the street and a 4-inch on the other. On single line streets, where they are being paved, the municipality insists on putting in the services with copper or lead, and we are making a service charge of $1.50 per year for looking after it.

# CONTAMINATION OF WATER SYSTEMS BY CONSUMERS WATER USES[1]

By S. B. Morris[2]

There have been many papers and many committee reports published in The Journal regarding cross-connections. The danger of contamination to domestic water systems through cross-connections has been recognized by many boards of health representing states and municipalities. State laws and city ordinances have been passed either seriously restricting or making entirely unlawful, the installation or maintenance of any cross-connection between a domestic water supply and any private source of supply not under laboratory control.

The City of Pasadena itself adopted such an ordinance a little over three years ago and requires all persons having any private water supply or storage to file a declaration of the non-existence of any cross-connections on their premises.

However, in review of water works literature, I do not recall any papers having been presented or restrictions drawn regarding piping and use of water by consumers after water has passed through the meter to their private premises. Before discussing the general possibility of such contamination, I should like to recite a few instances of contamination which have come under my observation.

One day we received a complaint of excessive lime in the water of a limited district. Upon investigation, we found that a water softening plant where water was treated for boiler feed purposes, was the cause of trouble. An elevated tank with pressure normally much less than that on the public water system stored this heavy dose of lime. During an emergency shutdown of the water main, a check valve on this line failed to operate and the lime water contents of this tank was drawn into the distributing system.

In another instance, we received complaint at a school cafeteria that excess chlorine in the water was discoloring the silverware.

[1] Presented before the California Section meeting, October 24, 1929.

[2] Chief Engineer, Water Department, Pasadena, Calif.

We knew this could not be the case as the territory involved received no chlorinated water. Upon investigation, we found that an ortho-tolidin test showed about one-tenth part per million of free chlorine at the cafeteria whereas a test from a fire plug directly connected to the city main adjoining the school showed no free chlorine. It was apparent that the cafeteria was receiving its water from a connection to the swimming pool circulation line which proved to be the case. Apparently a serious epidemic was only averted by continuous excess chlorination of the swimming pool water.

At another time, we received complaint of sewage odor in the showers at a public swimming pool. We immediately investigated and found the complaint justified. There was a sewage pumping plant about 500 feet from the swimming pool. At this plant horizontal, centrifugal pumps were used with automatic, intermittent operation raising the sewage from a concrete storage well up to the public sewers about 100 feet higher in elevation. The sewage pumps were located above the elevation of the sewage in the storage well necessitating pumps operating under a suction. The pump operator had had so much difficulty in priming these pumps that he installed a hose connection between a garden valve connected to the public water supply and used this hose to prime the pumps. Finally he had wired one end of this hose to a stop cock on top of the pump. At the time of the complaint, he had forgotten to close the stop cock and the pressure on the sewage pump line being in excess of the domestic water supply, caused accrued sewage to back up into the domestic water system actually contaminating the shower baths at the swimming pool.

In another instance, we received complaints of air in the water over a considerable area. For several months we were unable to discover the source of air of which the consumers complained. Finally, we found a water meter which registered backwards. Investigation showed that the machine shop and garage furnished by this service had an air compressor and air storage tank. In order to diminish the water bills, the proprietor of this shop had blown water back through the water piping reversing the water meter while the air passed off into the water distributing system. Probably no contamination occurred through this operation, but it illustrates the possibilities of water being passed through the meter into the distribution system.

From time to time new industrial or sanitary equipment offering

opportunities of contamination comes upon the market. The water utility has no direct knowledge of what equipment or piping is being installed by the individual consumer within his private premises. How is this matter to be controlled? I believe the only way is by coöperation with the building and plumbing inspection departments of the city. I am happy to say we have this in Pasadena.

One example of such devices will suffice. A certain Hollywood manufacturer turns out a douche cabinet to be recessed into the bathroom wall. Chemicals are added in this cabinet which is directly connected to the domestic water piping. If there should be any momentary failure of the water pressure, the highly poisonous contents of such cabinet would flow back into the water lines perhaps seriously affecting some one in another apartment.

Is the water supply to the swimming pool brought in over the top or is the pipe submerged so contaminated water may be drawn back into the water system if the water pressure falls and even a vacuum may be created on the piping? For that matter, do such hazards exist in a similar way in the bath tub, the laundry tray or the lavatory?

These are matters which should receive the joint study and thought of the water works operator and the city building and plumbing inspection service. We are all generally maintaining strict laboratory control over our sources of water supply. There is a possibility of contamination of water systems by consumers water uses. I have cited some instances of such contamination, and of faulty designed equipment offered to the public. Let every water works man give some thought to this problem and make the acquaintanceship of his building and inspection service of his community. Through their joint coöperation such hazards should be reduced to a minimum.

# HYDRO-ELECTRIC PLANTS IN CONNECTION WITH MUNICIPAL WATER SUPPLIES[1]

By P. L. Holland[2]

The problem of adequate municipal water supply has long been one of great interest and concern to the governing bodies of our cities and to the engineering profession. The rapid increase in our urban population, with an ever mounting per capita water consumption, together with the enormous industrial demands, result in problems of rapid recurrence. The mere definition of the word, "adequate," as used in this connection, is sometimes difficult. With carefully kept records covering years of operation it is sometimes impossible to predict the demands that may be made upon a water supply. A single industrial plant, such as some that have recently been constructed in the South, may consume water in such quantities as to endanger the adequacy of a supply that might otherwise be considered bountiful. One, or more, of our cities has failed to secure such industrial plants because of the inability to supply water in desired quantities.

In the endeavor to meet the increasing domestic demand, which is felt alike by large cities and small villages, and the contingency of sudden and enormous increments due to industrial demands, many of our cities have found it necessary to tap sources of such size and topography as to offer the possibility of power production as well as water supply.

When sufficient water is available, and particularly when more than one source is to be considered, the advisability of expending additional money for a combined plant introduces a number of questions which must be carefully studied. It is assumed, of course, in this discussion that the water from any one of the sources considered is of acceptable quality. The economic feasibility of power production under above circumstances must be determined by certain fundamental considerations.

[1] Presented before the North Carolina Section meeting, November 4, 1929.

[2] With Mees and Mees, Inc., Consulting Engineers, Charlotte, N. C.

The conditions encountered and considerations involved in the high head plants of the far west, such as the Los Angeles supply and the Hetch Hetchy development, are beyond the scope of this article. The magnitude of the Los Angeles project is evidenced by the contemplated delivery of over 200,000 h.p. in the city during the peaks of water consumption. This power is developed by the utilization of something over 400 second feet, average flow, through a head of over 2000 feet. Attention will be called to such conditions as may be met by the cities and towns of the Carolinas. In other words, power will be considered purely as a by-product. With few exceptions, plants of this kind will be of low or medium head, located some miles away from the community served, water cannot be used twice, that is passed through wheels, thence to water supply, and the power generated will be one of the two sources available, or desirable, for operating the pumping plant. To this end, the excess water at minimum streamflow, that is, the amount over and above the maximum demand of the water supply system, should be sufficient to pump said maximum and light the stations. Otherwise the highly desirable duplicate power supply for pumping must be obtained from another source.

To make a combined plant economically feasible, the cost of additional or larger structures and of equipment, properly chargeable to power production, must be such, not only to permit generation and use, or sale, of energy at a profit, as compared with existing available markets, but the net savings or profits must be sufficient to amortize the cost of the power plant in due time. In allocating capital cost to power plant and water supply care must be exercised to insure that all items not essential to a water supply alone are charged to power plant, unless the cost of these extra items result in operating savings to the water supply, in which case a proper proportionate part only should be charged to power plant. It is desirable that the power plant cost be amortized by the time the water demand equals the minimum streamflow. At this time the value of the plant as a generating station is greatly depreciated and, too, it may be necessary to seek additional sources and possibly, to abandon the existing plant. In the case of a probable plant life, based on availability of water, exceeding the life that might be expected on a depreciation basis, the regular depreciation only for equipment of that type should be charged against the power plant. In estimating the probable earnings of such a plant it is advisable

to err on the safe side and allow liberal maintenance and depreciation charges. It is inadvisable, under any circumstances, to permit the mere probability of a fair return to lead to the expenditure of excessive amounts of public funds. In the case of projected sales of surplus energy, it is advisable, for reasons which are evident, to make a long term contract covering the sale of such amounts as may be available.

In the case of a city already engaged in the generation and sale of electrical energy the considerations involved in adding to its generating capacity, in connection with its water supply, are vastly different from those that must govern in the case where surplus energy must be sold at dump power rates to a central station agency or to industrial plants. Assume, for example, a moderate sized municipal plant whose generating capacity is taxed to the limit during peak loads of short duration. Installation of additional capacity may involve new boilers, larger buildings, more or larger generators—probably interruptions to service. A hydro-electric plant in connection with the water supply might solve such a problem, perhaps with less capital outlay. The installed capacity in the hydro-electric plant would, in this case, be determined, very probably, on a peak load basis with very little regard to the annual output in kilowatt hours.

## EXAMPLES OF COMBINED HYDRO-ELECTRIC AND WATER SUPPLY PLANTS

As an example of a peculiarly advantageous contract for the sale of power from a combined water supply and hydro-electric generating station, attention is called to the agreement between the city of Springfield, Mass., and the Turner Falls Electric Company, covering power from the Cobble Mt. Station now under construction. This project is an example, too, of sound and conservative financing. The conditions as to topography, available head, etc., at this plant are more favorable than we may expect to encounter in North Carolina, in that the head averages approximately 400 feet and all water is utilized for power generation, the intake of the water system being located some distance below the tail race. The terms under which water is used for power purposes are of interest. The power company has leased the power plant and will pay annually for the use of plant and water approximately 25 percent of the cost of the power house, penstocks and hydro-electric equipment, which amount to

slightly more than one million dollars. As long as the water level in the reservoir is above certain designated elevations, depending upon the season and draft, the power company may use water at will. Should the level fall below the designated elevations, only the water required by the city may be passed through the wheels, and at the rate demanded by water consumers. The water capacity of the turbines is approximately ten times the mean flow of the stream, so that peak loads are readily handled, a distinct advantage to the power company. This contract runs for 30 years, which is the period of the longest serial bond issued by the city to finance the development. The earnings from this plant justify a much larger development than would have been possible with the income from the water system alone. The total cost of this project, including dam, electrical and hydraulic equipment, roads, etc. is estimated at $6,143,000.

Coming now to plants nearer home I quote from published data in regard to the plant recently constructed by the city of Spartanburg, S. C. I believe this plant has been described and discussed to some extent in previous meetings of this Association.

The power generating equipment of the Spartanburg plant consists of two 750-h.p. S. Morgan Smith wheels directly connected to two 625 k.v.a. G. E. generators, together with necessary switchboards and auxiliary equipment, the estimated cost of which was $395,000. The normal operating head is approximately 50 feet. The average power curve plotted by the designers of this plant indicates that for 25 percent of the time the generating plant may be operated at full capacity. It is, therefore, not a peak load plant. It is probable that the output might have been materially increased by the installation of larger generating equipment. The record for last year indicates an average load factor of nearly 60 percent. Last year's net earnings amounted to approximately $10,000 as compared to an estimated profit of only $6000. Earnings were computed as follows:

| | | |
|---|---|---|
| Power sold, 3,150,000 kwh. @ 0.5 cent | | $15,750 |
| Power used, 1,283,300 kwh. @ 1.34 cent | | 17,204 |
| | | $32,954 |
| Power purchased (night lighting, etc.) | $84 | |
| Interest and depreciation | 22,622 | |
| | $22,706 | 22,706 |
| Profit | | $10,248 |

The operation of the plant has been modified to a certain extent this year due to an agreement with owners of power plants located downstream. In order to compensate the owners of these plants for diversion of water, a plan has been worked out for storing water, when possible, during the week-end industrial shut-down period, Saturday noon till Monday morning, and releasing same at such times as to be of maximum benefit to the mills. Due to increased storage available the output of the lower plants will be increased, even with less water. The level in reservoir is being maintained at 10 feet below the crest, thus providing for flood storage, which may more than offset the slightly reduced head at the water plant. The net change in output will probably be small.

Another plant of this nature, the one recently constructed at Durham, N. C., is of peculiar interest. The choice, both as to location of plant and design of structures, was apparently not dictated by considerations of economy alone. The plant is located on Flat River approximately 10 miles from the city. Prior to 1917, and subsequent to that date, during periods of very low stream flow, water was obtained from the Eno River, at a point only 4 miles from the city reservoir. The location of the original Flat River plant at such an increased distance from the city and at a lower elevation, necessitating greater pumping head, was influenced, perhaps, by the presence in Eno River water of industrial wastes. Such pollution offers a problem which requires careful study, but one which is susceptible of solution. The site for the new plant was selected a short distance upstream from the steam pumping station on Flat River and has a drainage area of approximately 172 square miles. The dam is 80 feet high and impounds 4.6 billion gallons of water, a supply sufficient to carry over a prolonged period of drought. The height of dam was determined from considerations of storage alone, since the minimum flow of the river has been found to be approximately one-third of the present water demand.

The electrical generating equipment consists of three 500-k.w. 2300-volt vertical generators driven by S. Morgan Smith water wheels. An eleven panel switchboard is provided to control these units and for the necessary switching of electric pumps, etc. A 2300-v. to 22,000-v. sub-station of 1500-k.v.a. capacity is located adjacent to power house. Full load of all machines may thus be transmitted to the city for sale if available.

Two water wheel driven pumps and two motor driven pumps, all

of 5000 g.p.m. capacity, are provided. A traveling crane of 58 feet span may be utilized in handling any piece of equipment. Removable gratings permit its use in the basement. The equipment is all housed in one power house 77 feet wide, 103 feet long and 74 feet high.

The total cost of the project was not obtainable, or the proportion of cost chargeable to power generating equipment. According to the records of the city, the gross receipts from the sale of excess power amounted, for the last fiscal year, to $23,000. The power is sold to the Durham Public Service Company at 8.5 mills per kilowatt hour, a very attractive rate for dump power. The number of kilowatt hours sold was slightly less than 3,000,000. During an average year this amount would be materially reduced. The estimated mean flow of the stream should produce at 80 foot head approximately 8,000,000 k.w.h. per year. Considering the rainfall for the last year, the amount of probable yield and the amount sold, a very large pumping load is indicated. In the absence of detailed records it is not possible to accurately analyze the performance of this plant.

### SUMMARY

Summarizing briefly, in the consideration of a combined water supply and power plant:

1. Get accurate data on water available. This is important in any case, but greatly more so when the plant serves a dual purpose. Except in cases when enormous storage is possible, the absolute minimum flow must be known.

2. Allocate the estimated costs in such detail as to be able to predict with reasonable accuracy the savings to be made in the operation of the water plant and the earnings that may be expected from the sale of excess energy. Net savings or earnings only, must be considered.

3. Make arrangements in advance for sale of surplus energy, for the period that such energy will be available, or for as long a period as possible.

4. Study the set-up, determined as above, and if it is logical, build a combined plant. If there is doubt, stick to the essential water supply.

### MUNICIPAL OWNERSHIP OF POWER

The secretary of your association requested me to include in this article a complete discussion of municipal ownership and operation

of power plants and distribution systems. That is a very large order. I know of only two subjects that have been cussed and discussed more than municipal electric plants. The subjects are politics and religion. Right here I want to say that the greatest handicap ever placed on municipal plants has been too much politics and perhaps too little religion. The question of municipal operation is right now a very live one for several reasons. One reason is the concerted and determined effort on the part of central station agencies to buy up locally owned systems, in order to extend their markets. Considerable criticism has been leveled at the public utilities for offering in some cases apparently absurd prices for municipal systems. Sometimes the price offered is so much greater than the reproduction cost of plant, together with a generous allowance for "good will" that the temptation to sell is irresistible. Just bear in mind that, if a system is worth a certain sum to the utility company, it is, under proper conditions, worth just as much to the city or town. Assuming comparable rates for service and equal efficiencies in operation the municipally owned system should earn greater net profits than the system owned by the central station agency, due to the fact that the one is tax exempt and the other bears a heavy tax burden. The president of a large eastern utility made the statement a few weeks ago that, if his company were relieved of its tax burden, and the savings were applied to residential customers, the rates could be cut in half.

We have in North Carolina several examples of systems that are economically operated and which are sources of handsome revenue to the towns and cities. There is no magic word, or secret process, involved in the operation of an electric plant and distribution system. It is a clear cut, business proposition and when handled as such large profits are possible. The market is available and the demand stable and uniform. Possibilities in the utilization of electric energy are almost unlimited, and to that extent the market is steadily and rapidly increasing.

It is not difficult to understand, in many instances, why municipally owned systems are sold out. The plants are inadequate to meet the demands made upon them by an ever increasing load, distribution systems have just grown up, extensions being made here and there with little regard to line losses or delivered voltage. The operating personnel usually knows that the system is not what it ought to be, but funds are not always available to rebuild long sections of line,

rearrange feeders, replace transformers, etc. Sometimes engineers are engaged to revamp a system and as a rule the estimated cost is such a shock that the system is sold to the first utility representative who comes around. About nine times out of ten, as the first step, the utility company will rebuild the entire distribution system, stringing heavier conductors, placing larger transformers, in other words, putting the system on a money-making basis. The size of wire to be strung is not a matter of guesswork. It is fixed by a rigid economic law. The writer supervised the revamping of a system a few years ago, in which, under the former operation, the line loss and power leakage to ground amounted to 35 percent of the energy delivered to the system. Sound engineering advice costs very little and every town should avail itself of such service before selling out its electrical plant.

There are numerous comparisons that may be made between municipal and central station operation that may result in benefit to the municipality as regards ways and means of increasing the earnings of electric systems. One notable failure on the part of the average municipal personnel is apparent in almost all cases. I refer to the concerted drive to increase the sales and uses of domestic and heating appliances. These furnish a highly desirable off-peak load, which materially increases revenue. Of course, the utility company which usually operates a retail store makes a double profit, in the sale of the appliance and in the sale of energy consumed. In the case of a small town in North Carolina taken over a few years ago by one of our utility companies, the revenue, from the sale of appliances, during the first year, averaged more per customer than that from power sales. Those of you who live in cities supplied by central stations please note the constant campaigns being carried on to build up such load as referred to. It pays and pays well.

There is another point of view from which we may study municipal operations of electric systems. Take the cost of service to the taxpayer. Here we touch on one of the reasons why municipal versus central station operation is a very live question today. The rates charged by public utilities are based upon invested capital. Where fantastic prices are paid for locally owned systems, the result is reflected in higher rates to all customers of that company. With few exceptions, notably in Maryland and in Massachusetts, the utility commissioners, or other rate-making bodies, have not taken cognizance of values which even the executives of utility companies

admit are excessive. So long as rates are based on invested capital and not true physical value, it makes no difference to the central station how much they have to pay to get municipal or privately owned properties. It remains to be seen what effect the recent drastic readjustment of stock values which was felt particularly by utility companies, will have on earnings and, by reflection, on rates.

The interest and concern in regard to municipal operation of utility systems is evidenced in many ways and in many localities. A resolution was introduced a few weeks ago in the Boston Council looking to acquirement of the Edison system, which serves that city. Numerous small towns in the South, which have found out subsequent to disposal of their systems, that they, perhaps, overlooked golden opportunities, are seriously considering recapture of their plants.

One other idea I want to mention briefly in this connection. It is a plan that offers in some cases a great opportunity of profit-making. I refer to the sale of steam—district heating as it is usually called. In connection with steam generating power plants the production of power as a by-product, at a very small cost, is possible. The idea is being utilized generally in industrial plants and in some cities in the North. Bleeder turbines or back-pressure machines are used for power production at a very high thermal efficiency, and the exhaust steam then used for heating or industrial processes. The application is limited, and initial investment rather large, but earnings are attractive.

# LAYING OF WATER MAINS[1]

By Walter A. Peirce[2]

The first water supply developed in Racine was from artesian wells which had sufficient head to supply the consumers without pumping. When this source became inadequate a pumping station and system of mains carrying water from Lake Michigan was built by Boston capital and put into operation by the Racine Water Company in 1888. This plant was gradually extended and, after changing ownership several times, was purchased by the City of Racine in 1919, since which time it has been operated under a five man commission. The methods of construction have not been radically changed from those pursued since the original installation. The construction organization, which had been perfected under the able management of the late F. M. McElroy, has been continued by the commission. Upon taking over the plant, however, the city adopted a policy of special assessment for main construction which, of course, was a radical change. The cost chargeable to the abutting property cannot exceed that of a 6-inch main and credits of 80 feet are allowed on corner lots. This method of financing enabled many people to obtain water who would not have had access to it under the ruling of the private company which required a guarantee of 10 percent return annually before it would construct an extension.

The 31½ mile system of 1888 has now grown to one comprising over 130 miles of mains, through which some 8 million gallons of water are pumped daily to over 14,000 consumers. Twelve miles of mains are being built this year.

The commission feels that those who desire water sufficiently to pay the assessments should have it, and that the best supply possible should be developed, to which end over $500,000 have been spent on purification structures within the past five years. All improvements are paid for out of plant earnings without the issuance of bonds.

[1] Presented before the Wisconsin Section meeting, September 18, 1929.

[2] Manager, Water Department, Racine, Wis.

### PROCEDURE

Feeder main projects originate in the commission, but extensions to mains for service to abutting property originate in the common council which orders the mains constructed, either based on a petition from property owners affected or without such petition. The appropriate legal steps in levying assessments are taken by the commissioner of public works, and when completed, the water department is ordered to take charge of the work.

When the extension is first considered the manager prepares an estimate on a sheet called "Proposed Extension" to which a number is assigned. These numbers are in one series since the original construction and are retained by the completed extension. This sheet is letter size and carries data on the date ordered by the council, a sketch of the layout, the material list, and the cost estimate, the latter being reported to the commissioner of public works for use in assessment proceedings. An "Authorization Number" is also assigned to the extension and all charges of time and materials turned in by the foreman are charged to this number, an "Authorization Sheet" being made up and the complete itemized costs entered for final record. When the department has been directed to take charge of the work a written order is given to the construction foreman to proceed.

### MATERIALS

Pipe and fittings are purchased by public letting in the winter for early spring delivery resulting in considerable savings. All specials and a certain amount of pipe are stored in a yard adjacent to the pumping station and garage in the central part of the city, but where much work is being done in any particular locality an effort is made to obtain space for unloading and storage near the work. Valves, hydrants, lead and other materials are kept at the station storehouse and taken to the work as required. Pipe, fittings, valves and hydrants are subjected to inspection by the testing laboratory.

### CONSTRUCTION

The construction division operates only two trucks, employing outside contractors for hauling pipe to the street. A contract is let each year for excavating and backfilling trenches by machine at a unit price based on a seven foot ditch. All other work is done by department forces.

As soon as the foreman is ready to start on a street he has the pipe, valves, specials and hydrants and one or more tool boxes distributed along the work. He has the property line located, obtains the established street grade from the city engineer, and orders the trencher to start. As the trenching contractor is responsible for all underground structures encountered he makes arrangement with the other utilities to have services, mains and conduits located in advance of his work. Where the water trench closely parallels any particularly important conduits, such as toll cables or high tension lines, the contractor occasionally carries liability insurance. When the machine has progressed sufficiently the pipe is laid in the usual manner, the joints poured with lead and caulked with pneumatic hammers. No joints are covered until pressure is on them so that they may be inspected for leaks and any defects remedied. Backfilling is done by machine and settled by water using a hose with pipe attached after the dirt is in the trench.

Soil conditions are generally good, but, where poor, precautions are taken to prevent injury to workmen and to insure satisfactory construction. It is essential that the pipe be properly bedded, hydrants blocked so that they will not blow off and curves braced against solid earth.

Road boxes are used over valves up to 12-inch and manholes over larger sizes. Auxiliary valves are set on hydrant branches leading from all mains 12 inches and larger. This valve is usually the regular hub end valve for reasons of standardization, but in congested locations we are now using the valve which is bolted directly to the hydrant shoe.

REPORT AND RECORD

When the work is complete the foreman makes a written report of all materials used, detailing the weights and dimensions and indicating the labor involved. This is summarized and entered on the "Authorization Sheet" as well as on a "Completed Extension" sheet which is bound with the others and indexed by streets. The index shows extension and authorization numbers, year and book numbers. The "Completed Extension" sheet carries a sketch of the work as actually constructed, trench depth, nature of soil, valve and hydrant numbers, the latter being assigned for filing and record purposes. The foreman's report shows the location of all valves with reference to property lines and permanent structures.

## COSTS

A vast amount of data on cost of laying water mains has been published and numerous attempts made to develop formulae from which accurate estimates could be made in advance of construction. It cannot reasonably be expected that a curve of costs based on experience in one city will apply at another unless a rather complex formula be used in which the many variables are allowed to enter. Market conditions vary the prices of pipe and other materials; labor conditions are reflected in the cost of labor, sometimes not affecting all classes the same; work done by contract is quite likely to differ in cost from that done by force account, not always to the credit of the latter, and the quality of the resulting construction may also vary widely. In addition to these factors consideration must be given to the nature of the soil, number of underground structures, length of extension and many other things. When all this is taken into account the manager's judgment may as well be taken for the total cost as to be exercised in selecting a large number of factors which vary and which may produce a varying result.

TABLE 1

*Cost per foot of water mains constructed in Racine, Wisconsin, 1927–1928*
(Overhead costs not included)

| YEAR | SIZE | LENGTH | COST | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Per foot | Pipe | Specials | Lead and yarn | Valves and hydrants | Cartage | Labor |
| | *inches* | *feet* | *dollars* | *dollars* | *dollars* | *dollars* | *dollars* | *dollars* | *dollars* |
| 1927 | 6 | 9,814 | 1.91 | 0.90 | 0.03 | 0.07 | 0.20 | 0.02 | 0.70 |
| 1928 | 6 | 16,145 | 1.54 | 0.63 | 0.03 | 0.05 | 0.21 | 0.01 | 0.59 |
| 1927 | 8 | 2,848 | 2.19 | 1.07 | 0.06 | 0.09 | 0.26 | 0.02 | 0.69 |
| 1928 | 8 | 4,494 | 1.95 | 0.91 | 0.05 | 0.08 | 0.31 | 0.02 | 0.58 |
| 1927 | 12 | 6,759 | 3.80 | 1.89 | 0.12 | 0.14 | 0.30 | 0.10 | 1.25 |
| 1928 | 12 | 8,500 | 2.88 | 1.55 | 0.03 | 0.11 | 0.25 | 0.03 | 0.90 |
| 1928 | 16 | 7,158 | 4.47 | 2.18 | 0.11 | 0.16 | 0.26 | 0.10 | 1.67 |

The method of construction used in Racine and the system of records which treats each street as an individual extension gives us data from which it can be seen that there is a wide variation, more or less dependent upon the length of the extension and the artificial underground conditions. An example of this is a 16-inch extension

which cost $13.41 per foot, while the average for the same season was $4.47, ranging from $3.47 to $4.67 on 6,662 feet of work. This high cost was on a 64-foot street crossing where many cables and gas mains were encountered and where, due to the latter condition, special fittings had to be obtained with a considerable delay. Weather conditions were poor, which made it necessary to excavate much of the trench a second time and maintain lanterns and barricades much longer than is usual. The city regulation requiring sand for backfill of trenches in streets about to be paved increased the cost nearly $2.00 per foot.

On the final record entered on the "Authorization Sheet" our costs are divided into six parts: (1) pipe; (2) specials; (3) lead and yarn; (4) valves and hydrants; (5) cartage; (6) trenching, pipelaying, backfilling, tools and miscellaneous expenses. An overhead of 20 percent is charged to cover supervision, bookkeeping and other related expenses. The data for 1927 and 1928 in table 1 do not include overhead, but the foreman's time is included in the labor.

In 1928 costs average about 25 percent under those of 1927, over half of which was due to an advantageous purchase of pipe and the remainder a saving in labor on account of better organization and increased production. We expect 1929 to show a further reduction due to a still more favorable pipe contract and to a 50 percent larger program, although the trenching and backfilling price is 4 cents higher than last season. In 1927 this item was $0.21 per foot for a 7-foot trench which gave an average over the season of about $0.22, because a number of extensions were made in ungraded subdivisions. This year we have a flat rate of $0.26 regardless of depth.

It is planned to purchase our own machine for use in 1930, not with anticipation of much lower costs, but to facilitate the work in many ways and eliminate controversy as to amount of work to be done by the contractor where the machine has to lift up over obstructions. We have recently added a construction engineer to our organization who will have general charge of all extensions, preparing plans, organizing and laying out the work. We anticipate being able to execute our 1930 work to better advantage through these changes in organization and methods.

# A NEW MECHANICAL SAND FILTRATION PLANT IN COLORADO[1]

By Chester A. Truman[2]

The Northfield Land and Water Company is located in El Paso County, Colorado, and supplies water to the suburban area north and east of Colorado Springs, serving a population of approximately 3500 people. Its source of supply is taken from four storage reservoirs on West Monument Creek, in the Rampart Range of the Rockies, with a combined capacity of 600,000,000 gallons. The intake is located down stream 3.5 miles from Reservoir No. 1, constructed in 1888, and at fifteen hundred feet lower altitude.

Until last year, no provision was made for removing the suspended matter from the water other than a small settling basin and screen system. All was well as long as the three and one-half miles of open stream could be kept down to normal, but when the spring "run-off" came, or a hard summer rain fell, the stream would become swollen and quite turbid. Having no storage supply to draw from while the turbid water was by-passed for a few hours following a heavy rain, it was necessary to use it as it was or not at all.

While these periods were short, it usually put enough discolored water in the mains to extend over several days to a week before it could all be flushed out and clear water furnished again. This condition has been annoying, not only to the water users, but also to the water company ever since its first operation. The company has looked forward with much pleasure to the time when it could deliver to its users a sparkling water twelve months out of the year.

These short periods of discolored water presented the only serious problem in operating the system. Analyses of the water have always shown it to be free from contamination. Neither is there any hardness or minerals to cause any trouble. Therefore, a small, effective, not too expensive, economical filtration plant was the answer to the company's dream.

[1] Presented before the Rocky Mountain Section meeting, February 14, 1929.

[2] Superintendent, The Northfield Land and Water Company, Colorado Springs, Colo.

## DESCRIPTION OF NEW PLANT

It was decided to construct this unit in 1928, with a capacity of 2 m.g.d. The plant consists of a filter house with two filter beds, necessary pipe gallery, a coagulation basin, chemical house and a wash water basin. The old settling basin was used for a clear water well. We were very fortunate in having this settling basin located in a most advantageous position, which enabled us to use it as a clear water well, and to place the wash water basin on the same hill-side at its proper elevation, thus materially reducing the cost of the plant.

The filter beds have a sand area of 280 square feet. Each bed has three concrete wash troughs 4 feet 8 inch centers. There are 48 $2\frac{1}{2}$-inch wrought iron screw pipe laterals with 576 $\frac{5}{16}$-inch holes in the bottom. The header pipe is 10-inch steel, set in the concrete floor, with the necessary saddles riveted on for the lateral connections. The waste water valve is a plain 12-inch shear valve and so far has worked perfectly. Each bed is provided with an overflow pipe near the top.

The coagulation basin, 40 feet by 50 feet by 10 feet deep, joins the filters and pipe gallery on the west and has a capacity of 150,000 gallons and a retention period of 3 to 6 hours. The mixing well, 48 inches square by 10 feet deep, is located in the north-west corner of the basin, where the water enters under pressure from the intake 7000 feet west and with a head of 280 feet. This velocity causes quite a movement in this well where the chemicals are applied.

The water passes to the opposite corner into the 12-inch influent pipe. In the future when additional filter beds are added, baffles will be placed in this basin to increase the retention period. The walls of the coagulation basin are 10 inches thick on top and 14 inches at the bottom and are reinforced by eight conoforts, three each on the north and south sides and one each on the east and west sides. The mixing well and filters eliminating others on the east and west.

The chemical house is of one car capacity and is at the north-west corner of the coagulation basin with its floor on a level with the top of the basin. Here the dry feed chemical machine is run with a 6-inch Pelton wheel. Only one machine is used at present. We are trying the use of aluminum sulphate with sodium aluminate, which we use in the liquid form directly from a barrel. The plant was not completed in time for us to get a thorough test on this part of it in 1928, so the chemical treatment is still to be worked out. Since

August, the water has needed but little filtering and at present no chemicals are applied. We hope to perfect this part of the operation next spring.

The wash water basin stores 50,000 gallons of water and is located on the hillside just north of and 40 feet higher than the filter beds and is of the same construction as the coagulation basin. Water is pumped to this basin from the clear water well (just south of the filters) by a 4-inch centrifugal pump, through a 10-inch line. The centrifugal pump is run by a 36-inch Pelton wheel which is impelled by water from a by-pass line, drawn from the pressure line, which comes from the intake afterwards passing into the coagulation basin. Forty pounds pressure at this Pelton wheel will pump about 500 gallons of water per minute, and at this rate will fill the wash water basin in about two hours. This supply will wash a filter bed four times. Faster pumping is not practical because it would starve the main lines during the pumping period, since this is a gravity system, such a plan would interfere with users near the filters.

It is possible to by-pass the coagulation basin and run the raw water direct into the clear water well. It is also possible to by-pass the filter beds and run water from the coagulation basin into the clear water well. The coagulation basin, chemical house and wash water basin are so designed as to accommodate additional filter beds and pipe and fittings in the pipe gallery are installed in such a manner as to facilitate the construction of these additional beds.

All concrete is of reinforced steel construction, using Cripple Creek rock and bank sand, which was available near-by and the aggregate, when tested by the Pierce Testing Laboratories of Denver produced tests from 3200 to 4800 pounds per square inch. No water proofing was used in the concrete. However, a small amount was painted on the inside of the coagulation basin and the wash water basin. The coagulation basin had a few damp spots on the outside after testing, but the wash water basin has never had a spot.

The buildings are of stucco and Spanish tile and by happy choice of color scheme, the whole plant is blended into the landscape to present a very unique and pleasing appearance.

No difficulty in operation has been experienced except in air-binding of filter beds. After they were used a month or so, about 3 inches of the fine stock sand was removed from the top of the beds which helped. However, these beds will still air bind occasionally.

As yet no regular attendant has been in charge and except possibly

two months in the spring, we do not expect to have one. The operating expense, therefore, will be just about what the coagulation chemicals cost.

No heating is required. All piping is either protected or drained when not being used, thus eliminating that expense. The pipe gallery is much warmer than might be expected because of the ten feet of water on the west and ten feet of earth on the north and a small embankment on the east.

We could not well close an article descriptive of our filtration plant without acknowledging the splendid assistance we were accorded by those in charge of the two best known filtration systems in this part of the country, Fort Collins and Marston Lake and also the hearty coöperation and kindly suggestions of Dana E. Kepner, State Sanitary Engineer.

Since a registered engineer is required for an improvement of this nature and since R. M. Reid, who has served in this capacity for the Northfield Company over a considerable period of time was not available at the moment, G. H. Garrett, associated with The Thompson Manufacturing Company of Denver, was secured as consultant. His criticisms were always constructive and were made in a manner appreciated by The Northfield Company and by the contractor on the job.

In addition to the above we are greatly indebted to the fellowship and ideas developed in these meetings of our Association.

In presenting the following cost figures, it should be remembered that we were guided by a strict economy in construction consistent with a thoroughly efficient plant and that we were favored by excellent working conditions and choice of location:

| | |
|---|---|
| Cost of concrete in place, 463 cubic yards | $8,726.26 |
| Cost of buildings in place | 2,742.24 |
| Cost of pipe installed | 3,370.99 |
| Cost of machinery installed | 728.39 |
| Cost of engineering, grading, supervision and incidentals | 2,832.54 |
| Total cost of plant | $18,400.42 |

# SERVICE INSTALLATION[1]

By Orla Casad[2]

Installation of water services is a problem for the manager of every water system. One should standardize water service connections to meet local conditions, making them large enough to give good uniform service. What I mean by good service is a connection that will deliver to the consumer the amount of water he requires in a reasonable length of time.

The use of water should be spread over as long a period of time as good service will permit, in other words, so that the peak demand will be of short duration. By doing this the efficiency of the distribution system will not be impaired.

The size and number of service connections greatly affect the balance of a water system, and for that reason much more thought should be given to the installation of water services than is accorded generally.

Pipe used for water services should be of material that does not decrease in carrying capacity and that is affected the least by soil conditions. The merits of all material should be given very careful consideration.

In 1888 the Merced water system was installed, and AA and AAA lead pipe was used for services until copper service pipe was introduced in California. I believe we were among the first to use this material and to date we have found it satisfactory in every way. Cast iron pipe is used for connections larger than 2-inch.

The residential lots in Merced are 50 by 150 feet. We install $\frac{3}{4}$-inch connections for practically all residences on such lots.

We maintain approximately 40 pounds pressure in our distribution system. Operating under these conditions we receive practically no complaints from the consumers.

[1] Presented before the California Section meeting, October 24, 1929.

[2] Superintendent, Water Works, Merced, Calif.

# INDUSTRIES AND WATER SUPPLIES[1]

By Wellington Donaldson[2]

The speaker has considerable hesitancy in discussing a subject so ancient as this and about which so much has already been said. Yet in spite of the plethora of literature on the subject, the multitude of investigations relating to it and the litigations involved thereby, it is surprising that some important phases of the subject are being continually overlooked not only by industrial contributors to pollution but by water works people as well.

It is somewhat remarkable, too, that the heaviest pressure for the elimination of stream pollution comes nowadays not from the management of water works properties, but from conservationists in the general sense, having the least financial interest in the condition of the streams and the least responsibility in preserving their purity. This statement applies particularly to those who are interested in having preserved the attractiveness of water courses, the restoration of fish life and the expansion of recreational facilities. These ambitions are laudable and sane, but obviously deserve secondary consideration to the preservation of streams as suitable sources of public water supply.

It is of course well known to you that The American Water Works Association has had the subject of trade waste pollution under study since 1920 by a standing committee which has made interim reports. This Committee No. 6 of the Standardization Council, of which the writer was once a member, in its progress report to the 1922 Annual Convention, in Philadelphia, (The Journal, 10: 415) gave the result of a preliminary survey showing about 250 public water supplies adversely affected by various trade wastes. This number represents only a small per cent of the some 8000 public water supplies existing in the United States at that time, although it comprised some large communities representing a considerable aggregate population. The Committee made no claim that its list of affected water supplies

[1] Presented at the Kentucky-Tennessee Section meeting, January 25, 1929.

[2] With Fuller and McClintock, Engineers, New York, N. Y.

furnished a complete picture of the situation. On the contrary, the list should be taken as representing only the outstanding examples or aggravated cases known to the committee through published experiences or through personal contacts of its members. Common sense must indicate that practically every water supply drawn from streams which drain well populated areas must be affected in some degree by trade wastes. In a majority of cases fortunately the effect of such pollution is unappreciable. Quite frequently, however, the effect of the wastes is recognized and duly appraised, but so long as no serious difficulties attend, nothing is done about the matter.

The committee report referred to offered a classification of the industrial wastes into seven groups based on the nature of the substances and their observed effects on water supply. For the present discussion, a simpler but more general grouping will be considered.

The water works experiences are generally comprised in the following situations:

(1) The wastes cause nuisance and complaints, but the water works is lacking in the purification facilities considered proper to the protection of its consumers.

(2) The wastes give rise to obvious nuisance and complaints from water consumers on account of taste, odor, or appearance in spite of well designed and carefully operated purification facilities.

(3) The wastes, on account of nature, quantity or irregular discharge, are likely to upset the operation of water purification processes and therefore constitute a potential or actual hazard to the health or life of water consumers.

(4) The wastes may be satisfactorily purified without undue hazard to the hygienic or physical qualities of the water supply, but their presence imposes a financial burden on water consumer or tax-payer.

The first situation calls for little comment. If the municipality fails to provide itself with those purification facilities usually considered requisite for the handling of a surface water supply, it is in a weak position for complaining about the acts of others. For instance, if filtration is indicated for the particular supply and filtration would easily remove the effects of the particular trade waste, there would be little point to the complaint of damage being done by the small addition of suspended matter.

Of the second group it is also proposed to say little here because these situations are well recognized and are the ones usually dealt with in discussions of this subject. Public convenience is a powerful

factor in dealing with conditions where the water supply contains objectionable odor and taste or is not satisfactory in appearance due to the introduction of obnoxious substances, the sources of which are easily traced. Most of the court decisions relating to the pollution of water have been concerned with nuisance situations of this kind. The best known examples are the discharge of phenolic substances from coal and wood distillation, the discharge of salt water from oil well operation, the discharge of various putrescible materials such as canning, creamery, tannery and sugar wastes which impose a burden on the stream and result in bad taste and odor, or the discharge of intensely colored liquids. Some of the wastes are not susceptible to any known methods of water treatment; others are only partially responsive.

Regarding the third situation, water plant operators are usually well informed, but its importance has not been sufficiently stressed and therefore is not appreciated by industries responsible for the condition. Neglect of this phase of trade pollution is shown very strikingly in some recent papers dealing with this subject and also in some comprehensive stream investigations completed or now in progress, where undue emphasis is given to the items of dissolved oxygen, biological oxygen demand and biological surveys. Such studies are admittedly of great value in evaluating stream conditions, but may have little or no bearing on the difficulties of water treatment plants obliged to purify the water.

To obtain a satisfactory quality of water from a surface supply we must realize that the tools of purification consist of a limited number of steps, namely, plain sedimentation, clarification with chemicals, filtration, and disinfection.

Sedimentation, of course, is not a critical process and does not even form an invariable part of water purification plants. With coagulation the case is different. The coagulation of some natural waters, unpolluted with trade wastes, is very difficult at times and the process, although universally practiced in connection with rapid sand filters and in some cases in connection with slow sand filters, is not yet under perfect laboratory control. However, it is undeniable that many kinds of trade wastes do interfere markedly with coagulation, either on account of inorganic substances which exert a harmful buffer effect or the addition of substances which act as protective colloids against coagulation. The action is more pronounced in the case of intermittent dumping of the harmful substances and during

periods of low stream flow when the concentrations are more pronounced.

The loss of coagulation at the water plant generally means deterioration in physical quality of the water, lowered bacterial efficiency, both in basins and filters, and possibly loss of disinfection. With a heavily polluted source of supply the effect may be quite serious on the public health.

The proper functioning of the rapid sand filter is dependent upon adequate preparation of the applied water. If the applied water is not properly coagulated, filtration efficiency is impaired. The filter beds may become clogged with foreign matter to the point where they do not function properly.

Disinfection and chlorination are practically synonymous terms in water works practice. The importance of the process is related closely to the character of the particular water supply. Where the supply is relatively free from sewage pollution, chlorine may be regarded simply as an additional safeguard, but in the case of supplies subjected to heavy bacterial loading, chlorine becomes a vital link in the chain of purification processes. Any interruption may have serious consequences to the community served. The amount of chlorine effective for disinfection is small, usually 0.2 to 0.5 p.p.m., the requisite being that a definite residual shall be maintained in the treated water. Chlorine readily combines with inorganic reducing agents such as ferrous sulfate, sulfur dioxid, sulfides, sulfites, hyposulfites, etc., and with many kinds of organic matter. It is readily apparent, therefore, that intermittent dumping of wastes of this character into the source of supply may nullify without warning the disinfecting power of chlorine and thus impose a serious hazard on the water consumer.

The third situation is an economic one. We assume here that the waste substances discharged into the stream do not cause complaint from the consumer, or impose undue hazards to the hygienic quality of the water, but do increase the cost of furnishing satisfactory water. This can be best illustrated by a few examples. The addition of caustic lime causes first an increase in hardness, followed by a decrease as softening takes place and in extreme cases may be followed by another increase in hardness. Soluble salts of calcium and magnesium increase the hardness in direct proportion to the amount added. Slight increments of hardness may not be appreciable because the natural stream is continually undergoing variations in

this constituent, yet each increment affects indirectly the pocket book of every consumer of water. Estimates of the cost of hard water are variously set up. It is commonly assumed that each part per million of hardness requires 0.1 pound of soap per thousand gallons of water and that 1 gallon per capita is softened with soap. For a population of 100,000 people, therefore, so trivial an amount as 1 p.p.m. increase of hardness of the water supply means 10 pounds additional soap per day used or, say, $730.00, per annum increased outlay by the community for soap, to say nothing of the attendant effects on steam boiler plants, hot water heating devices, etc. Now no one would quibble about the addition of 1 p.p.m. of hardness, but what about an increase of 10, 50, or 100 parts? Are these economic considerations to be passed over lightly?

Suppose we take now the matter of operating chemicals. It is no uncommon thing for industrial wastes to increase the required coagulant dose of alum by a grain per gallon. This means for a community of 100,000 an increase of about 1430 pounds of alum per day at the filtration plant or a yearly increase of, say, $7300 in the operating expenses of the department.

Similarly an increase in the chlorine dosage, the necessity of using lime or soda to assist coagulation and to combat corrosion, the labor required for overhauling filters, etc., are inevitably accompanied by an added expense to the tax-payer, the water consumer or the stock holders. To what extent is a water department justified in submitting to these or similar increases in operating expense before complaining and seeking a remedy? Where a definite, though endurable, damage is known to be done to a water supply by long established industries, what ought to be the view of the water department towards the encroachment on the watershed of additional industries which would greatly increase the troubles at the water plant and the expense of treatment? The writer does not attempt to provide answers to the questions raised above.

In the case of existing stream pollution where large investments are involved it has been the experience both in this country and elsewhere that the most good can be accomplished by coöperation between the contributors of pollution and the sufferers therefrom. Statutes exist in most of our states against stream pollution, but they have been generally ineffective on account of the obvious confusion which their strict enforcement would cause to the prosperity of the state as a whole. Especially noteworthy at the present time is the

policy adopted by Pennsylvania, Ohio, North Carolina and Wisconsin whereby agreements are made between the state boards of health and the industries providing for a coöperative study of the problem and the abatement of unnecessary pollution.

What about the handling of new industries coming into the state? Some control is needed to prevent these new industries from usurping the streams to the detriment of not only water supplies, but of other industries as well. This problem is of special interest to some of my listeners who are from states having abundant undeveloped resources and which are eagerly inviting capital to become established. It is proper under these circumstances to have adequate assurance that in developing some resources the water resources will not suffer materially. It is prudent that new industries before deciding to locate in any particular locality should take into consideration not only the factors of raw material, transportation, labor, power, etc., but should include also a careful study of stream pollution situation. In many cases it is not unreasonable to expect industries to install in connection with new processes recovery or treatment methods for excluding stream pollution, where such methods have been demonstrated to be feasible.

# VARYING WASH WATER RATES WITH CHANGES OF WATER TEMPERATURE[1]

By W. C. Lawrence[2]

Filter plant operators throughout the country know that rapid sand filters get in a very bad condition by late summer, due to what is termed a "hang back" of organic matter in washing. The sand piles up around the edges of the filter beds and cracking then takes place throughout the beds, especially a pulling away from the edges. This condition produces a bad effluent water, because around the edges of the boxes where the sand has pulled away, the water passes down very rapidly without filtering through the sand. Just inside of the outer edge, where the sand and the organic matter have piled up, the water to be filtered meets with a higher resistance and the rate of filtration is decreased considerably below the desired normal rate. With the normal rate of wash this condition is not rectified, but throughout the summer steadily becomes worse and is not improved until late fall or early winter, as the organic matter decreases. The best conditions seem to exist in the center of the bed.

For the last 30 years, since the high velocity wash was adopted and universally used throughout the country operators have washed their filters at a fixed rate. This rate has generally been within the range of 15 to 27 inches per minute rise. These rises are generally fixed by the engineer designing the plant, depending upon the head of wash water over the strainer system, the size of wash water valves, size and depth of sand, and the amount of freeboard and size of wash water troughs and gutters.

After two years of operation, the Baldwin filters began to go bad in the late summer of 1927. I was not surprised, having had charge of the Division Avenue Filter Plant since it was first put into operation in 1917, where I had experienced somewhat similar bad filter conditions every year.

At Division filter plant, I tried prechlorination, washing at longer

[1] Presented before the Central States Section meeting, September 18, 1929.

[2] Superintendent of Filtration, Baldwin Filtration Plant, Cleveland, Ohio.

time periods, raking of sand and digging up around the edges of the beds to loosen the sand, taking it out and passing through ejectors to scrub the sand, even taking off the top surfaces and replacing with finer sand, but all to no avail, the beds would return to a poor condition after passing through a summer, when we always have practically no turbidity, but a high content of organic matter and microörganisms.

At the Baldwin filter plant, I was surprised to note the sand piling up around the sides of the filters up to a certain height and then occasionally caving in and causing a bad filter effluent. This bewildered us, since at the Division Avenue Filter Plant we experienced a similar piling up and cracking of the beds, but no caving in. Both plants have filters of the same area, a very similar strainer system, equal wash water pressures, and in general almost the same conditions, except the size of the sand. The original sand size at Division was 0.45 mm. and Baldwin 0.38 mm.

The treated water received by the filters at both plants is practically the same, with the exception that the raw water delivered to Baldwin plant passes through the Fairmount reservoir (an open reservoir with a detention period of 16 to 24 hours), which during the summer months greatly increases the organic matter. This increased quantity of organic matter and the finer sand seemed to cement together with such tenacity that the wash water could not break through and would therefore be diverted toward the center of the bed. This eventually hollowed out a hole and undermined the piled up portion of the bed. After reaching a certain size the pile would collapse, leaving a hole and exposing the surface of the fine gravel. This collapse would take place when the filter was in operation, which meant that there was a downward suction. At this time unfiltered water would readily pass through and the effluent samples would show poor results.

After experiencing the filters breaking in this manner, about the late summer and early fall of 1927, I was fortunate in receiving a copy of the formula which Mr. Hazen devised for filter washing.

Mr. Hazen's formula is as follows:

$$\text{Rate} = 30\, d^{1.5}\, (1 + 0.060\, X)\, \frac{(t + 30)}{80}$$

Where $d$ = effective size of sand in millimeters

$t$ = temperature of the wash water, °F.

$X$ = percent expansion expressed as a whole number.

Example:

$$d = 0.40,\ X = 50, \text{ and } t = 55°\text{F.}$$

$$\begin{aligned}\text{Rate} &= 30\ (0.40)^{1.5}\ (1 + 0.06 \times 50)\ \frac{(55+30)}{80}\\ &= 30 \times 0.252\ (1+3)\ (85/80)\\ &= 7.56 \times 4.0 \times 1.0625\\ &= 32.13 \text{ inches rise per minute.}\end{aligned}$$

In the summer of 1928, I constructed a small filter in a glass tube about $1\frac{13}{16}$ inches in diameter, using 30 inches of sand having an effective size of 0.48 mm., and a uniformity coefficient of 1.30, and plotted the sand expansion for various rises of wash water and found that the actual expansions as measured checked very closely with Mr. Hazen's formula.

### PLANT VARIATIONS IN WASH WATER WITH TEMPERATURE

While this work was being conducted in the laboratory during the month of August, we took one large filter unit in the plant where the sand condition was poor and increased the wash water from 24 to 39 inches rise per minute which gave a 50 percent expansion. As the temperature in the fall kept decreasing, we reduced the rise in the attempt to maintain approximately the 50 percent expansion. While this work was in progress we took actual measurements on the rise of wash water, the height of the sand during the wash, collected bacterial samples of the effluent, and noted the general appearance of the bed. As a result of this experimental work it was decided to increase the rate of wash water at both Division and Baldwin filter plants during the year 1929 as the temperature of the water increased, maintaining at Division plant about 40 and at Baldwin a 50 percent expansion. At Division plant, the maximum wash water obtainable was a 29-inch rise. But at Baldwin we have been able to continue through with our program. The wash water system will give a 39-inch rise of water which is the maximum required for a 50 percent expansion at the water temperature of 73°F., the maximum water temperature for this year. The water has now reached this temperature and the 24-inch wash water valves are practically wide open, resulting in a 36-inch rise per minute.

The schedule which we are using for washing filters at the Baldwin plant is as follows:

| DEGREES FAHRENHEIT | INCHES RISE PER MINUTE |
|---|---|
| 32–42 | 24 |
| 42–52 | 28 |
| 52–62 | 32 |
| 62–72 | 36 |
| 72–Max. temp. | Approx. 38–39 |
| 72–62 | 36 |
| 62–52 | 32 |
| 52–42 | 28 |
| 42–32 | 24 |

From the beginning of the year up to April 1st the entire 40 filters were washed with a 24 inch rise per minute. On April 1st the water having reached 42°F., we increased 39 of the filters to a 28-inch rise, leaving one at the 24-inch rate for comparison.

On May 14, the water having reached 52°F., the valve stems on 38 filters were again changed so as to produce a 32-inch rise leaving two filters of the 40 unchanged, one at 24 and one at 28-inches rise.

On June 5, 37 wash water valves were further opened so that a 36-inch rise was obtained, leaving one unchanged at the previous rate of 32 inches.

On July 18, 36 filters were increased to a 39-inch rise of wash, leaving one filter at the 36-inch rise. This final increase of wash water resulted in all but four filters being washed at a 39-inch rise, and the wash water valves all being practically at their full open position. The other 4 filters, each of which were located in the center of a quadrant of 10 filters, are being washed with rises of 24, 28, 32, and 36 inches respectively. We are now comparing these 4 filters with the other 36, as to the length of runs, amount of wash water, bacterial reductions, sand analyses, and general appearance of beds as regards cracking and piling up around the edges of the bed.

We found after increasing the rise to 39 inches, that by the time the wash water valve had reached its full open position, sand was being lost, so that we immediately cut back to the 36-inch rise. This loss of sand would probably not have taken place had the sand been perfectly clean; but due to the organic matter surrounding each sand grain, the specific gravity was less than for clean sand, and therefore floated over the steel weir plates.

At Baldwin we have a 30-inch sand bed. However, it would be uneconomical and unnecessary to lose sand, as I immediately found that the 36-inch rise was scouring off the organic matter in fine shape.

After each increase of the opening of the wash water valves, as the temperature of the water increased, according to schedule, we determined the rises on each unit by leaving the sewer valve closed and timing the rise with a stop watch. After the rise was set, we measured and recorded the length of the stem in the wash water valve for future use in setting the valves after the temperature started decreasing.

### DETERMINATION OF SAND EXPANSION

With a long pole, to which shallow copper cups, a quarter inch deep, were attached and spaced around the pole in a spiral fashion so as to have the tops of the adjoining cups about $\frac{3}{8}$-inch apart, we measured the rise of the sand bed and determined the sand expansions. This form of measurement was not very satisfactory. The first work done on expansion, was to measure the distance from the top of the sand bed to the edge of the weir plate just after the effluent valve was closed. By keeping the pole at this original elevation, we measure the height to which the sand rose during washing. Knowing the depth of the sand and noting the sand deposit in the cups, we determined the expansion. In order to compute the expansion we arbitrarily assumed to use the highest cup that was completely filled with sand as indicating the rise of the sand. We often found some sand in the cups three or four positions higher. I believe this to be due to the sand being incrusted with organic matter and thereby having less specific gravity than the remaining sand in the bed. Later on we found that there was a difference of $\frac{3}{4}$- to 1-inch in elevation of the top of the sand bed, depending on whether the elevation was determined before or after washing the bed. The bed was always lower just after closing the effluent valve, due to the suction of the water being filtered, pulling down and compacting the bed. Accordingly we discarded these methods of determining the elevations.

We then placed the base of our sampler on the top surface of the gravel, while the wash was in progress, and measured the height of the sand in the cups. This method also gave inaccuracies, because originally we had exactly 30 inches of sand in the beds and a distance of $25\frac{1}{8}$ inches from the top of the sand to the edge of the weir plate. This made a total of $55\frac{1}{8}$ inches from the gravel to the edge of the weir plates; but when placing the sampler on top of the gravel we had measurements as high as 60 inches and in the bottom cups found small torpedo gravel. This showed that with this very high velocity we were floating or tending to displace the fine gravel.

The method finally employed was to measure from the edge of the weir plate down to the cup filled with sand during the wash. Then after the wash was over and the sand had settled back to its original level, we measured that distance from the weir plate and that gave us the present surface elevation of the sand bed. Substracting the figure found from the full cup of sand to the weir plate, from the distance of the sand to the weir plate, we arrived at the true expansion. Knowing the depth of the sand bed and the amount of expansion, the percent of sand expansion during washing was obtained. This figure was then compared with the one obtained by using Hazen's formula, and the results were found to be fairly comparable; the actual measurements of expansion being slightly higher than those calculated from the formula.

Of course, the condition of the sand and sizes have changed slightly during the summer with increased rises from time to time due to scouring off of the organic matter, with the loss of some of the fines.

## RESULTS

From an operating point of view we have accomplished the following results:

The appearance of the beds have been greatly improved, looking cleaner, with the elimination of the piling up or cracking around the edges.

Thirty-six percent longer filter runs and 16 percent saving in wash water over the previous year have been effected.

Bacterial results on the filter effluent water have not improved this summer, due to the mud accumulation being scrubbed off and allowing the enmeshed bacteria to pass through. Better results are anticipated from now on.

Costs have been reduced, due chiefly to the saving of costly wash water. No additional equipment is required to produce better beds and less chemicals probably will be required when the beds are always in the good condition.

The simplicity and the ease of operation make this method desirable and practicable.

# WATER SOFTENING AT HINSDALE, ILLINOIS[1]

By H. Menold[2]

Hinsdale, Illinois, is a city of 8000 people, located 18 miles west of Chicago. Its proximity to Chicago offers many advantages as a homesite to the city dwellers and a continuation of Hinsdale's steady growth is anticipated. Increasing population means increased water consumption and provisions have been made to insure an adequate quantity of potable softened water for the residents of Hinsdale.

Water obtained from deep wells having a hardness of about 480 p.p.m. was Hinsdale's sole supply for many years. All the home and factory troubles caused by continued usage of hard water were experienced throughout the city.

In 1915 a water softening plant, consisting of a chemical house and two steel tanks of 250,000 gallons capacity each, was constructed and placed in service. One tank was used for reaction and softening, while the second was used for storage purposes. Lime and soda ash were the only chemicals used. Later alum treatment was added. However, the alum treatment was never a success due to an undependable feeder. This type of plant softened the hard well water for several years. Although softening of the city supply successfully solved the hard water problem, many other problems soon developed, the most important of which was the pipe line incrustation. This trouble was caused by the after reaction and precipitation of the slow reacting salts in the water. This feature along with others was given serious thought as the continued growth of Hinsdale and the resultant increased demand for water made it obvious that a larger plant would soon be needed.

Before planning the new municipal water softener, all the defects of the old plant and troubles arising from the distribution and use of softened water were carefully tabulated and studied. In addition, advantage was taken of all the latest developments in the water softening industry.

[1] Presented before the Illinois Section meeting, March 30, 1928.

[2] Superintendent, Water and Electric Light Plant, Hinsdale, Ill.

## DESCRIPTION OF RECENT PLANT

The new plant costing in excess of $100,000 was put under construction in August, 1924. Operation was started in September, 1925. The plant was designed for a maximum of 3 m.g.d. It has all the modern equipment, utilizing mechanical agitation in the mixing tanks, dry feed machines for chemicals, a clarifier for continuous removal of sludge, a pump for the repumping of sludge, and a carbon dioxide machine. The plant is constructed on a unit plan so that the present outlay can be expanded when necessary.

The raw water carrying a hardness of about 468 and an alkalinity of 375 is pumped from a deep well equipped with a deep well centrifugal pump. The raw water is divided between two mixing tanks entering at the bottom. Hydrated lime and soda ash are fed into the mixing tanks by automatic proportioning dry feed machines. Alum was formerly added at this point and in the same manner. The repumped sludge is also added and the whole is mechanically agitated. The treated water passes from the mixing tanks to a long trough where 34 percent liquid sodium aluminate is added, proportioned by a small motor driven pump. The water passes next to the clarifying basin where a majority of the solids are precipitated and then it goes to the settling basin. From the settling basin the treated water passes over a weir to the carbonating basin where the carbon dioxide is added. After carbonization. comes the filters and storage.

The Hinsdale raw water in September, 1926, had a hardness of 468 and an alkalinity of 375 (all figures in parts per million.) At that time this was the hardest water being softened by any municipality. Furthermore this water is very difficult to soften, because of the high magnesium content. The consulting chemist recommended a finished water having a total hardness of 85, total alkalinity of 85 and twice the phenol alkalinity of 85. Considerable difficulty was encountered when an attempt was made to reach and maintain an 85 part water. Lime, soda ash and alum would not react and give this quality of treated water without imparting considerable excess caustic alkalinity. Excessive caustic alkalinity, in turn, increased the work of the carbonator. To reduce the overloaded carbonator and the excessive caustic alkalinity while securing water of standard 85 parts, it was decided to try the then new alkaline coagulant and softening chemical sodium aluminate.

## EXPERIENCE WITH SODIUM ALUMINATE

Since sodium aluminate is alkaline, it is unnecessary to increase the lime and soda ash as with the acid coagulant alum. As a matter of fact, sodium aluminate permits a reduction in the soda ash charge. In addition, faster reaction and better coagulation are obtained with sodium aluminate and a softer water may be delivered from the plant.

Prior to the use of sodium aluminate, the water was treated with 3.15 pounds of hydrated lime, 0.933 pound of soda ash, and 0.13 pound of alum per 1000 gallons, resulting in a water from the Dorr clarifier, with a total hardness of 157, alkalinity 147, with 23 p.p.m., of caustic alkalinity. This water was then treated with 3.3 pounds of hydrated lime, $\frac{3}{4}$ pound of soda ash and 0.28 pound of liquid sodium aluminate, resulting in a water with 87 p.p.m. total hardness, 85 alkalinity, and only 15 of caustic alkalinity. Thus, by substituting $\frac{1}{4}$ pound of the liquid sodium aluminate for $\frac{1}{8}$ pound of alum and increasing the lime 5 percent and decreasing the soda ash 18 percent, a water was obtained with almost 45 percent reduction in total hardness. Note that this remarkably lower hardness was accomplished with 8 parts lower hydrate excess, even though the potential hydrates from lime and sodium aluminate were increased. This treatment resulted in a reduction in cost of chemicals of 4.1 percent, a marked reduction in the total amount of water used for backwashing of filters and a reduction of 21 percent in the total amount of gas used for recarbonization.

These comparisons were made on operation with alum during the early part of September, 1926, and with sodium aluminate during the latter part of November of the same year. Comparison of the results obtained with alum, during September, 1926, with those obtained in September, 1927, using sodium aluminate, showed greater improvement. The total amount of water used for filter backwashing had been reduced 64 percent and the gas consumption had been reduced 36 percent. In 1926, when alum was used, the percentage of backwash was 2.6. During September, 1927, the percentage was 0.94. This remarkable decrease in the amount of water used for backwashing was due to the improved coagulation obtained by the use of sodium aluminate, which improved the settling in the Dorr clarifier. During the use of alum a scale of considerable thickness formed on the walls of the filters and basins. Continued use of sodium aluminate has removed practically all of this scale.

It has been our observation, particularly with a high magnesium raw water, that a high grade of hydrated lime must be used. A good grade of soda ash should always be used, although a slight variation in the soda ash quality does not so materially affect the results. All chemicals should be bought on specifications which will insure a much more uniform quality.

We are now planning to start a test of the 84 percent solid sodium aluminate which will be proportioned and fed by a new type of feeder recently perfected. We hope to duplicate the results obtained by the use of the liquid material.

I hear few complaints from the users so I have concluded that for household and drinking purposes we are supplying a finished product that is generally satisfactory. Our people are proud of the water softening plant both because of its efficiency and its fine appearance.

## CHLORINATED COPPERAS IN THE TREATMENT OF SOFT, HIGHLY COLORED WATER[1]

By A. Clinton Decker[2]

During the early part of 1928, the writer in coöperation with the Alabama State Board of Health and the Alabama Water Service Company, lessee of the water works property at Chickasaw, Mobile County, Alabama, undertook a series of experiments to determine possible methods of treating the water from Eight Mile Creek, a stream originating in springs and flowing through heavily cypress wooded territory. The turbidity of the water in this Creek is normally very low, usually 3 or less; while the maximum turbidity rarely exceeds 25, although some analyses have shown 50. The alkalinity ranges from 2 to 5, while the color varies from 40 to 130 p.p.m. The pH varies from 5.5 to 5.9. The bacterial content is usually under 100 per cubic centimeter.

The first experiments were carried on with one-gallon bottles and also with an experimental filter 12 inches in diameter. Good coagulation and color removal could be obtained by the use of 5½ g.p.g. of alum and 3 g.p.g. of lime. Ferrous sulphate and lime, however, failed to produce coagulation and seemed to set the color. During February, 1929, further bottle experiments were conducted, using chlorinated iron sulphate along general lines suggested by L. H. Enslow of the Chlorine Institute. Work was also done with alum, lime and soda ash.

During the time which had elapsed between the completion of the experiments made in 1928 and the work undertaken in February, 1929, a filtration plant had been designed by C. P. Rather, Chief Engineer of the Alabama Water Service Company, with the writer cöoperating. Construction had progressed to the point where it was possible to begin operation of the plant on April 11, 1929. Bottle experiments, carried on for two days preceding the date of placing

[1] Presented before the Water Purification Session, the Toronto Convention, June 27, 1929.

[2] Sanitary Engineer, Tennessee Coal, Iron and Railroad Company, Birmingham, Ala., and Chickasaw Utilities Company, Mobile, Ala.

the plant in operation, indicated that 1.0 g.p.g. of chlorinated copperas alone; 1.0 g.p.g. of chlorinated copperas with 0.2 g.p.g. of sodium aluminate; 1.0 g.p.g. of chlorinated copperas and 1.0 g.p.g. of lime; all produced a good floc which precipitated with varying degrees of rapidity and color removal. With these figures as a basis, the plant was put in operation using an initial dose of 0.8 g.p.g. of ferrous sulphate, oxidized with 0.11 g.p.g. of chlorine, and with 0.33 g.p.g. of sodium aluminate introduced into the second unit of the mixing chamber, about 4 minutes after the introduction of chlorinated copperas. Good coagulation and color removal were noted in the first bay of the coagulating basin, while the filter effluent was entirely satisfactory.

Using varying amounts and combinations of coagulants, with the introduction of lime at several different points in the coagulating basin and in the clear water well, uniformly satisfactory results were obtained by using 0.7 g.p.g. of ferrous sulphate, oxidized with 0.126 g.p.g. of chlorine and using 0.55 g.p.g. of lime to adjust the alkalinity and pH. Lime was introduced in the clear water well. The introduction of lime in the coagulating basin seemed to set a small amount of color. The most satisfactory results were obtained by the introduction of lime in the clear water well. However, with a maximum color of 3, when lime was introduced in the coagulating basin just before the water passed to the filters, the results even under these conditions were considered satisfactory. During part of the time that the plant was operated experimentally, sodium aluminate was used. When this was done best results seemed to be obtained by the use of 0.4 g.p.g. The results obtained both with and without sodium aluminate were entirely satisfactory. There was a difference of opinion among the observers as to whether there was any substantial difference in the character of the filtered water when sodium aluminate was used and when it was eliminated. Sodium aluminate made coagulation more positive when the amount of other chemicals varied from the quantities giving optimum results.

Final results, after lime treatment, show pH to be from 7.0 to 7.2, alkalinity 7 to 8 p.p.m., color not more than 3, bacteriological results conforming to the standards required by the United States Public Health Service.

The plant, with a rated capacity of 1,000,000 gallons per 24 hours, is to be operated intermittently since the present demand for water is only about 20 percent of the rated capacity of the plant. The

experiments were made, therefore, on the basis of continuous and intermittent operation, with comparatively little difference in results.

All experimental work described in this paper was conducted jointly by H. G. Menke, Assistant Sanitary Engineer of the Alabama State Board of Health, and myself. During the experimental operation of the plant, we were fortunate in having present for observation and for suggestions, C. P. Rather, Chief Engineer of the Alabama Water Service Company; C. Arthur Brown, Chief Engineer, Bureau of Water Purification, American Steel and Wire Company; and G. R. Kavanagh of the Wallace & Tierman Company.

Mr. L. H. Enslow, of the Chlorine Institute, although unable to accept our invitation to be present, offered valuable suggestions in the experiments.

Although these results cannot be considered as final, due to the fact that the plant has been in operation for only a short period of time, it has been demonstrated conclusively that the use of chlorinated copperas as a coagulant for this type of water is practical, efficient, and economical. By the use of chlorinated copperas, a saving in cost of chemicals of approximately $10.00 per million gallons was made possible.

## *DISCUSSION*

Edward S. Hopkins:[3] Considering the mechanics of color removal, a study of the floc formed under such conditions is of interest. This study was made with the highly colored water from Elizabeth City, North Carolina, which has the following characteristics:

| | *p.p.m.* |
|---|---|
| Color | 300 |
| Turbidity | 8 |
| Alkalinity | 18 |
| Hardness | 30 |
| Iron | 2 |
| $CO_2$ | 22 |
| pH | 5.6− |

Coagulation was obtained with this water using an initial dosage of 2 g.p.g. chlorinated copperas, stirring 5 minutes and then adding more or less simultaneously 1 g.p.g. of lime and an additional 2 g.p.g. chlorinated copperas with subsequent stirring for an additional 10

[3] Principal Sanitary Chemist, Montebello Filters, Baltimore, Md.

minutes. The color obtained in the filtrate from water so treated was reduced to 10 p.p.m. with practically no iron in the solution. The floc gave every indication in relation to appearance and color of being that of typical $Fe(OH)_3$.

Since this form of stirring device simulates the mixing basin at this plant and since it is possible to obtain very accurate comparisons in dosage of coagulants between the laboratory and plant, it is believed and assumed that the results so obtained are comparable to plant practice.

Careful analysis of the floc formed as described, indicates that it consists very largely of an organic iron complex. It was quite possible to establish definitely the composition of the mineral components of this floc, but, on the other hand, practically impossible to determine with accuracy the organic constituents. A formula of $Fe_2O_3 \cdot 2SiO_2 \cdot 4X$ seems to be the proper one conforming to the data obtained when X stands for the organic constituent. The relation of 4X was determined by its ratio to the mineral components, i.e., the organic relationship is 4 times that of the added coagulant and the amount of turbidity present.

This floc seems to be obtainable at a very low pH value, namely 5.6 and less and is in sharp contrast to the floc obtained by the use of lime and iron, which is most effective at pH 9.4 or above.

These results indicate that chlorinated copperas has a definite place in coagulation for color removal.

# TAKING HARDNESS OUT OF WATER[1]

By R. E. McDonnell[2]

Hardness in water is almost entirely due to calcium and magnesium dissolved from rocks and soil with which the water has, in its travels, been in contact. The divisions of regions, then, of hard and soft water is along geological rather than state boundaries. Certain states, however, by reason of their geological formations, are known as "hard water" and "soft water" states.

The "hard water" states, whose waters average in hardness from 200 to 500 p.p.m., include: South Dakota, Nebraska, Kansas, Oklahoma, Iowa, Illinois, Indiana, Florida and Arizona. The majority of these states draw their water supplies from wells.

Thirteen states are grouped under an average hardness of 100 to 200 p.p.m. This group covers more surface supplies and less well supplies, and consists of California, Utah, Wyoming, Colorado, New Mexico, Texas, Missouri, Arkansas, North Dakota, Minnesota, Wisconsin, Michigan and Ohio.

Seven states have an average hardness of from 50 to 100 p.p.m. They are: Nevada, Idaho, Montana, Kentucky, West Virginia, Tennessee and Pennsylvania.

The states enjoying soft water, or an average of less than 50 p.p.m., are: All the New England States, the Atlantic States, three Southern States (Louisiana, Mississippi, Alabama), and, in the Northwest, Washington and Oregon.

Local geological formations frequently exist that may account for hard water supplies in states where the average hardness is low.

The concentration of population is much greater in areas where soft water is available for public water supplies. The city seeking manufacturing industries has a very great handicap against its becoming an industrial center if its water is hard.

Hardness of water is of two kinds—temporary and permanent. In most waters the calcium and magnesium are present as bicarbon-

[1] Presented before the Rocky Mountain Section meeting, February 15, 1929.

[2] Consulting Engineer, Kansas City, Kans.

ates. The hardness, due to this much of the calcium and magnesium, is called "carbonate hardness" or "temporary hardness," which can be largely removed from water by addition of lime or zeolite. Permanent hardness or non-carbonate hardness is more difficult of removal and requires soda ash or the zeolite process for its removal. The total hardness of a water is the sum of the temporary and permanent hardnesses.

The average water user knows water is hard if a large amount of soap or washing compounds are required to break the water or produce suds or lather. The use of soap serves to soften water for domestic use and is necessary because water has but little cleansing power until soap has neutralized the calcium and magnesium salts. There is a loss or wastage of one-fifth of a pound of soap per 1000 gallons for every part per million of hardness. For a water of 300 p.p.m. of hardness, with a population of 40,000, one ton of soap would be wasted per day. With an average cost of 5 cents per pound for soap the loss would be $100.00 per day, or approximately $1.00 per person per year, which is an economic waste or loss for the community with a hard water.

Hardness in water means to the chemist that there is in solution carbonates, sulphates, and chlorides of calcium and magnesium. If they are removed the water is no longer hard.

To the layman, the water user, the housewife, the bill payer and the water superintendent not familiar with chemistry water is water. As long as it is clear, free from bacteria and plentiful, there is no cause for complaint; and nothing is done about it. The average citizen goes on complacently paying soap, laundry, fuel heating, plumbing, pipe cleaning, linen renewal, cosmetic, and innumerable other bills—all higher than they should be and some entirely unnecessary—all because there is too much hardness in the water.

Taking the hardness out of water is a municipal function. It is a duty and an obligation the water officials owe to the public. The house water-softener manufacturers discovered that a home owner would be willing to pay a stiff price for the privilege of having soft water in his home. The average first-cost of these home installations is about $300.00, plus a constant high operation cost; making them prohibitive except to the wealthier class. A municipal plant can be put in at moderate cost, and would serve all water users, and at an operating cost averaging one-twentieth of the operating cost to the family fortunate enough to have its own water softener.

The rapid increase in the number of municipal water softening plants is due, in a large measure, to the economy of municipal softening as compared with expensive individual or "home" softening. Considered in terms of per capita costs, the original investment for municipal softening is one-tenth that of individual softening, and the operating costs for a community softener is but one-twentieth that of a home softener.

The softening of waters for municipalities has been accomplished simultaneously with their filtration and at a slight additional cost above filtration. The new filtration plants throughout the country now being designed should provide for the necessary equipment for softening water as well as removing its other impurities. At the present time about half the population of America is drinking filtered water and many of these filter plants could, at small cost, be rearranged for both softening and filtration.

In a surface supply requiring filtration for removal of impurities and where a carbonate hardness of over 100 p.p.m. exists, it would be financially sound to soften the water.

The additional construction cost of providing softening equipment would probably not exceed 10 percent above that of filtering equipment alone, increasing somewhat if both temporary and permanent hardness are removed.

If a ground water supply is used the whole cost of treatment must be charged to water softening.

If the surface supply requires filtration and the carbonates are high, justifying a lime treatment, the lime serves as a purifying as well as a softening agent. Lime is a most effective and economical germicide. Quick lime is preferable to hydrated lime because of its lower first cost; but, it has a higher softening value than hydrated lime. It can be purchased in bulk, and, for the larger plants, can be unloaded with a vacuum airveyor, lifting the lime to bins, thus avoiding any disagreeable lime dust. The lime can be unloaded by airveyor equipment in sizes below 2 inches and at a cost as low as 10 cents per ton. The lime from the bins drops by gravity to weighing hoppers, thence into slackers.

One pound of lime at $12.00 per ton or 0.6 cent per pound will soften as much water as 20 pounds of soap at 10 cents per pound. In other words, softening with lime costs only three-tenths of one percent as much as soap softening. When we realize that at least one percent of the total volume of water pumped into the distribu-

tion system is used as a cleansing agent it is evident that softening of the entire supply is economical. Soaps used in excess may be harmful to the skin. Another objection is that the reaction of soap with the calcium salts produces a scum which collects in the bath tub and in the fabrics we are attempting to clean. For every pound of lime added, three pounds of limestone sludge are removed.

The bacterial efficiency of softening and coagulating basins over simple coagulating basins, with the use of lime as a softening agent, has been clearly demonstrated after two years of operation of the Springfield, Illinois, water softening, iron removal and filtration plant. The average efficiency of the basins, as measured by the B. coli index during this period, was 99.2 percent. Compare this high efficiency with that of 75 percent given in the Manual of Water Works Practice. A basin with 99 percent efficiency can handle twenty-five times the load that can be handled by a basin of 75 percent efficiency with the same quality of effluent. In many cases money can be better spent on a softening plant than on settling basins, giving better results in purification, plus the advantage of having soft water.

In taking hardness out of water sufficiently to make it satisfactory for all domestic and commercial uses, in a public supply, it is best not to reduce the total hardness below about 75 to 100 p.p.m. Below that would merely add materially to the operating costs, with no appreciable advantages.

A water with excessive hardness, say, 700 p.p.m. or more, should be studied from the standpoint of comparative cost of treatment with the cost of procuring another source of supply.

With our present knowledge of softening ground water supplies it has been possible to utilize many well supplies formerly rejected because of high mineral content.

Iron, magnesium, sulphuretted hydrogen and other objectionable minerals or gases occurring in excessive quantities, sufficient to give disagreeable taste or incrustation, can all be removed by the one operation.

The removal of red and brown stains and incrustations in service pipes has been the chief cause of the popularity of the modern water softening and treatment plant.

A study of the chemical analyses of the water will soon show the nature and contents of the chemicals, and from this the experienced waterworks engineer can readily report the character and kind of

treatment required. It many cases this cost of taking hardness out of water, including iron removal and recarbonation, has not exceeded one to two cents per thousand gallons.

The lime process is just another means of removing carbon dioxide which enables calcium carbonate or lime to remain in solution. The lime combines with the carbon dioxide, forming calcium carbonate. This cannot be accomplished in the case of permanent hardness salts, such as calcium or magnesium sulphates.

To avoid depositing carbonates in pipes, mains, meters, services, etc., the water must be recarbonated by carbon dioxide or ordinary flue gas so that any residual carbonates will remain in solution.

This recarbonation further serves to give the soft water a snap and sparkle, and prevents flat taste. It is a simple, inexpensive treatment that restores the taste of the soft water to what it was before softening.

Taking hardness out of water by the zeolite process is the common method of household softeners and is simply an exchange of sodium for calcium and magnesium in the waters treated. When the zeolite materials have lost their power to soften completely, the materials are regenerated by passing through the apparatus a strong solution of common salt. The exchange silicate softeners take all the hardness out of water, but do not work well with turbid waters.

The question is often raised as to the effects of hard or soft water upon the human system. Occasionally statements have been made as to probable harmful effects of each kind of water. After much research the best authorities agree that no appreciable harmful effects have been demonstrated from the long continued use of either very hard or very soft waters.

The average family can enjoy at a cost of 7 cents per month, the benefits of soft water. The savings by reason of soft water come principally to the home owner or whoever pays the annual household bills, rather than to the municipality.

The annual saving in soap alone averages three times as much as the annual cost of softening the water with lime. The largest saving comes in decreased fuel bills by reason of less fuel required for heating where a non-scale water is used in heating plants. This saving runs from 5 to 10 percent of the annual fuel bills.

To a housewife the soft water brings longer life of fabrics and linens; one bar of soap where four were formerly required; no frequent replacement of heater coils, toilet and plumbing fixtures; ab-

sence of stains in wash-bowls, toilets, and sinks; little, if any, incrustation in hot water service pipes.

Soft water is not a luxury, but a household necessity and economy.

No investment by the city gives greater returns to its citizens. Of all municipal improvements, none has proven so universally popular as plenty of pure, soft water. Cities with soft water are industrially in a position to assure new industries of at least 10 percent less annual operating production costs by reason of soft water.

# DETAILS OF FILTER PLANT OPERATION[1]

By Arthur J. Hall[2]

The operation of a filter plant efficiently requires that certain portions of the work should follow a definite daily schedule. These operations can be carried out in the following manner:

1. Daily inspection of plant, such as rate controllers, loss of head gauges, chemical tanks, orifices and chemical feeding equipment.
2. Making of tests and recording of results in a systematic and intelligent manner.
3. The care and washing of filters.
4. A small amount of research work that may create better and more efficient plant operations.

## INSPECTION OF PLANT

The inspection of a plant is usually made the first thing in the morning and consists of a thorough inspection of orifice boxes to insure their feeding of coagulants regularly and to guard against stoppage. The solution tanks should be looked after to see that the mixing equipment is in operation and that the solution is of uniform and proper strength. In the event that dry feed machines are used for the feeding of chemicals, these machines should be checked frequently for their accuracy. The coagulation of the raw water at the inlet of the settling basins and also on the filters should be examined. This is done by collecting a sample of water in a clean, clear glass. The coagulant should be plainly visible and flocculent. The settled water should have a visible turbidity of about 20. If the turbidity of the settled water is greater than 20 and if the aluminum sulphate is used alone the dose should be increased. If the water is excessively turbid it is well to try applying part of the coagulant at the center of the settling basin. The excessive turbidity of the settled water may also be caused by the settling basins being excessively dirty.

[1] Presented before the Wisconsin Section meeting, September 17, 1929.
[2] Superintendent, Water Works, Appleton, Wis.

Weekly, or better, twice a week each filter should be examined. This is best done just previous to the time of washing the filter. The investigation should include:

1. The condition of the sand
2. The process of washing
3. The rate of washing
4. The rate of filtration
5. The operation of rate controllers and loss of head gauges

The filter to be examined should be shut down and the water level lowered below the sand by opening the rewash valve. The general appearance of the mat should be noted and a sample of the sand should be taken. The filter is then washed and the rate of wash determined. Any uneveness in the distribution of the wash water should be noted. The entire sand bed should be floated and this can be determined by having a long pole and thrusting it into the filter until it reaches the gravel. If the filter is washing properly, the pole will penetrate to the gravel bed with no obstruction. A tin can attached to a stick should be held near the troughs to note whether any sand is being lost. After washing the filter, again draw down the water to observe the effect of the wash. The sand should be perfectly level and free from humps or hollows. There should be no patches of mud or mud balls, but a uniform thin film of coagulant is advantageous. The wash water line should have a meter in order that the amount of water used for washing can be checked.[3]

A novel method of determining the coagulation of the raw river water, the condition of the settled water and filtered water was designed by the writer.

A glass tank consisting of three compartments, each one square foot in size and holding a cubic foot of water, was constructed. This glass tank is mounted on a cabinet made in design to compare with our operating tables and to house the necessary piping to the tanks. Below the glass tanks which form the top of the cabinet, a piece of white vitrolite glass was placed on an angle of about 22½ degrees. Three 50-watt daylight blue lamps were placed in back of this vitrolite glass in such a manner that the rays of light would be transmitted up to the water against a white illuminated background.

This observation tank was placed in the lobby of the filter plant where it is in constant view of the operators and where visitors coming

[3] Patent Pending, Serial Number 4152441.

into the plant would be able to observe the condition of the water at its various stages in its travel through the purification system. This observation tank is placed in an elevation in the plant where the water flows by gravity to it. These tanks are supplied with the inlet on the bottom and the overflow near the top, the water being continuous in its flow through them. One tank was labeled "Raw river water;" the second, "Settled water;" and the third "Filtered water."

The raw river water is supplied to this tank immediately after coagulation as the water enters the settling basin. Its purpose is to have a continuous visible picture of the character of the river water and of the coagulation. The second tank contains a continuous sample of settled water which also gives a continuous picture of the efficiency of the settling basin. The third tank or compartment contains a continuous sample of the filtered water as it leaves the filter plant on its way to the high duty pumps. I have had this observation tank in use for approximately six months and consider it one of the most valuable methods of control for the operators and a picture before them at all times of the results of purification. The tank has also been of great interest to visitors and others interested in water purification. I have just recently constructed an experimental filter 12 inches by 12 inches by 72 inches high and have this filter placed along side of the observation tank. This experimental filter is placed at an elevation that the settled water goes to it by gravity and it can be operated in unison with the large filters. It is constructed entirely of glass and the formation of the coagulant and the process of washing is made visible. This likewise has been interesting and attractive to visitors.

## CHLORINATION

The process of chlorination and the care of chlorinating equipment should require constant attention by the operators. Too much stress cannot be put in instructing the operators on the need of accurate and constant application of chlorine. For the past two years we have been using prechlorination with wonderful results. In prechlorinating we add two-thirds of our chlorine dose to the water immediately after it is aerated and before it enters the sedimentation basins. Prechlorination has resulted in a saving in alum, longer filter runs, with better conditions in the sand beds and with the elimination of mud balls on the filters.

## OPERATION OF THE FILTERS

The ultimate efficiency of any filter plant depends to a great extent on the care and the proper manipulation of the filters, no matter how perfect the coagulation or sedimentation. The maintaining of a suitable rate is most important owing to the fact that the coagulant forms a gelatinous blanket on the surface and the upper part of the sand which really is the real medium of filtration and which is broken by excessive velocities of the water. The filter capacity should be ample so that the rate shall never exceed 125,000,000 gallons per acre per day corresponding to about two gallons per square foot per minute. The load should be distributed on all filter units equally, an important detail often neglected. All filter control equipment should be kept in first class working condition and each filter should be equipped with a sampling cock so that samples can be taken from each filter.

## TESTS

It is perhaps needless to say that the making of tests and the intelligent interpretation of the results obtained is the keynote to success or failure of any purification plant. Tests should not be made only as general routine with the recording of the results in a mechanical way. The laboratory is the control unit of the plant and the results of the tests should conscientiously control the purification process.

All laboratory apparatus should be carefully calibrated and kept scrupulously clean. All glassware should be cleaned in an acid cleaning solution. Petri dishes should be washed clean in an acid solution and rinsed in clean water and allowed to dry, never using a towel for drying. All glassware should be sterilized for two hours in a dry oven at 180°C.

All culture media should be standardized carefully and great pride should be used in preparing all culture media so that it is clear and a pleasure to use. Chemists are sometimes judged by the character and looks of their culture media. An electric refrigerator should be regular equipment in any well-equipped laboratory for the storage of culture media. The dehydrated culture media on the market represent a great saving in time over the old method of preparation and furnish reliable and accurate results. All samples should be carefully taken. It is preferable to make use of a tap or spigot in the collection of the sample, rather than submerging the sample bottle in a tank. The plating of all samples should be carried out

in a room free from currents of dust. It should be done when the chemist is in the laboratory alone, as any visitor tends to disturb him and is a great cause of discrepancies in results.

### THE OPERATION OF SMALL PLANTS

The operation of the small plants represents a problem to the small communities. The water supply of a small village is just as important to the individuals of that community as it is to those of a large city. Their lives are just as valuable and they are entitled to just as pure a supply of wholesome water as those in a large metropolis.

However, the size of the water utility in a small community is such that the income from the utility would not warrant the employment of a full-time chemist and bacteriologist. At the present time the water purification plants in most of our municipalities are efficiently and economically conducted. In the near vicinity, however, there may be a small village operating its plant in the darkness and in a hit and miss fashion. Some of these small plants are entirely ignorant of their aimless drifting, but the great majority would welcome a helping hand. It is surprising how easily they may be guided into the right channel. A visit to the plant, simple instructions in the chemistry of the plant operation, an occasional analysis and explanation of its interpretation by a trained water expert will in most instances fall on fertile soil. A large number of small plants are now being controlled by supervising chemists with a great improvement shown in their operation. The supervising chemist is kept actively interested in all the problems of his profession and is able to give these advantages to small communities who would not otherwise perhaps ever hear about the changes in progress. Village officials often feel that their technical supervision of small plants is an unnecessary expense, but the value of a safe water supply can scarcely be over-estimated. In many instances the increased efficiency obtained offsets the cost of technical supervision.

### GENERAL REMARKS

I could not complete this paper on details of filter plant operation without saying a few words on the publicity that should be given to all water works plants.

The attitude of the public towards filtration in towns where a plant has just been installed is often one of doubt and skepticism. This feeling is generally augmented by statements made by some

professional men and others who know nothing of the process, but whose words carry weight because of their supposed scientific attainments. For purely commercial reasons those engaged in the sale of bottled waters, etc., will misquote filter records. The best way to overcome this tendency is by publicity. Keep the plant up to date and open to visitors at all times. Make the city water works an outstanding feature in the city in which the citizens are all proud. Explain the workings of the plant and have diagrams, pictures and models that will assist you in making clear your explanations.

Have descriptive literature always available on your water works and occasionally write an article for your newspaper.

The operator should feel himself under moral responsibility to furnish at all times a hygienically safe water, this duty preceding all others. This is especially true because any return from a pure to an impure water, even for a short time, is almost certain to be followed by an epidemic of intestinal disease in the community, regardless of the fact that the same water had been used with immunity for years before filtration was started.

# RAPID DETERMINATION OF THE COLON GROUP[1]

By Max Levine[2]

From a consideration of the rates of growth of the coli aerogenes group in broth it is contended that, if one organism capable of growing in the medium is introduced with 10 cc. of water into 30 cc. of broth, after an incubation period of 10 hours at 37°C. there should generally be over 2000 bacteria in the tube or 50 per cubic centimeter. The number of these organisms is too small to show any visible evidence of growth, such as gas formation. If, however, 0.1 cc. were smeared over the surface of an eosine-methylene-blue agar plate, the organisms introduced onto the plate (theoretically at least 5) would grow very rapidly as they are in their logarithmic growth phase (i.e., the stage of most vigorous growth) so that colonies would develop very quickly, generally in 12 to 16 hours, on this solid medium. If these plates and the preliminary enrichment medium are both kept at 37°C. then those plates made from tubes which show gas the next morning (24 hours presumptive test) should have colonies of the coli-aerogenes group (partially confirmed test).

A number of samples of the Missouri and Iowa river water were tested in this way and it was found that in over 90 percent of the trials, E.M.B. plates made after 10 hours incubation from tubes which proved to be positive 24 hour presumptive tests were positive for the partially confirmed test. Thus the standard presumptive and partially confirmed tests may be obtained simultaneously in 24 hours if speed is necessary or desired.

[1] Presented in abstract before the Missouri Valley Section meeting, November 7, 1929.

[2] Professor of Bacteriology, Iowa State College,, Ames, Ia.

# A PECULIAR LACTOSE-FERMENTING ANAEROBE FROM FILTERED AND CHLORINATED WATER

By Robb Spalding Spray[1] and Paul C. Laux[2]

The city water-works of Williamson has for some time experienced considerable difficulty in producing a filtered water which does not show gas formation in lactose broth tubes. In the attempt to overcome this trouble chlorine has at times been added to give a residual, by orthotolidin, of 0.4 p.p.m. in the clear well and 0.15 p.p.m. at the city taps. Even at this concentration the fermentation persisted, and strenuous complaints were aroused by the taste of the delivered water.

Gas rarely shows within 24 hours, but at 48 hours from 30 to 100 per cent may be present. Platings from these tubes to eosin-methylene-blue agar very frequently remain sterile. The obvious explanation of such a situation would be anaerobic fermentation, and studies were conducted along this line.

During the same period another difficulty has been experienced with the filter-beds becoming "air-bound," especially during the summer months. At such times the filters operate at an increasingly lower rate, and when cut out of service, gas (air?) escapes for 15 to 20 minutes.

It is not improbable that the "air-binding" and the problem of positive presumptive tests may have a common explanation, although this question has not yet been thoroughly studied.

## GENERAL CONSIDERATIONS

Williamson obtains its water from the Tug River. Part of the city sewage, and all from a number of coal camps, enters the river above or dangerously near the pump intakes. The intakes are located opposite the center of town, and the plant itself is located within the city limits largely on account of distribution costs.

[1] Professor of Bacteriology, West Virginia University Medical School, Morgantown, W. Va.

[2] Superintendent, Water Works, Williamson, W. Va.

The water is taken from the river by downward infiltration through a gravel and sand-filled concrete pit, 65 feet by 25 feet by 12 feet deep, sunk in the river bed. This prefiltration bed reduces the turbidity by 80 per cent or more, and diminishes the bacterial count of the raw water some 60 to 75 per cent.

This prefiltered water is then treated with alum and lime, then passes to two sedimentation basins of 270,000 gallons total capacity, where a sedimentation period of $2\frac{1}{2}$ to $4\frac{1}{2}$ hours is allowed. Four filter beds of 176 square feet area each are in intermittent operation, with a unit capacity of 500,000 gallons, although ordinarily run at a rate of about 375,000 per 24 hours.

Chlorine is applied by the usual pulsating chlorinator, being added at the entrance to the mixing tank. Chlorine dosage has been very high, especially during the summer and fall periods of difficulty, running frequently over 1.0 p.p.m., and even then many lactose broth tubes show gas with 10 cc. samples at 48 hours. Gas never shows at 24 hours, and *B. coli* is never confirmed from these tubes. The residual chlorine runs around 0.5 p.p.m., and many complaints are received as a result.

## LABORATORY STUDY

Due to this continued difficulty the problem was referred to the University laboratory for study. At first two cultures isolated at the plant were submitted for identification. These proved to be *B. subtilis* and *Alkaligenes bookeri*, Bergey et al.— neither of which ferment lactose with gas, and were evidently of no significance.

Two original fermentation tubes which had showed gas were then submitted. Inoculation from these to lactose broth, freshly boiled showed no gas at 24 hours; at 29 hours fermentation was active, and at 48 hours from 80 to 90 per cent of gas was present in the inverted vial, and a strong odor of butyric acid was evident.

Gram stains from these tubes showed a slender Gram-negative bacillus and a large Gram-positive coccus, chiefly in pairs. Aerobic plates of lactose-litmus agar inoculated from these tubes yielded an apparently pure cultue of this diplococcus, with no evidence of acid formation. Pure cultures of this coccus did not ferment lactose broth, and the organism was discarded without further attempt to identify.

Anaerobic plates of lactose agar inoculated from these tubes and incubated in the Novy jar, exhausted by vacuum and pyrogallate,

did not show growth. Deep shake cultures in dextrose and lactose agar, both with and without casein digest, some covered with paraffin oil and others with vaseline, incubated at 37°C. and at room temperature failed entirely to show any perceptible growth. Control shake cultures of *Cl. tetani*, *Cl. botulinum* A and B, and *Cl. welchii* all gave abundant and typical anaerobic colonies. Up to the present we have been unable to obtain colonies in any solid medium except gelatin under vaseline, incubated at room temperature. In gelatin (pH 7.6) the colonies were first perceptible at 6 days, and at 11 days were nearly 1 mm. in diameter, spherical, and fairly compact with a slightly furry periphery. In gelatin (pH 6.0) the colonies developed earlier, being perceptible at 3 days and of maximum size of about 1 mm. at 8 days, and were looser and of more fluffy texture than those in the more alkaline medium.

We assumed, from the chlorine resistance, that the organism was undoubtedly a spore-former, and being unable at first to grow isolated colonies, attempted to segregate by heating deep egg-meat cultures. Broth was removed from such cultures to small sterile tubes which were heated 1, 2, 3, 5 and 10 minutes at 85°C. Inoculations were then made to freshly boiled lactose broth. Growth failed to appear after only 1 minute heating, and it would appear that there were no spores present in the egg-meat culture after 4 days incubation.

Spores have been sought by stain and microscopic study in every medium in which the organisms grow, but have never been observed with certainty. In old acid sugar broth cultures the organisms swell into peculiar shaped forms, some of which appear like subterminal spores. However, by Moeller's spore stain no spores have ever been demonstrated. Heating of these cultures has not demonstrated any spore-like heat resistance. We should note, however, that these cultures were all strongly acid, since we have never grown the organism successfully except in the presence of a fermentable sugar.

Colonies in gelatin were not obtained until late in the study, and for early isolation we were forced to rely on the old dilution method by which lactose broth tubes (pH 6.0) were inoculated daily for 3 days to allow the organism to proliferate at the the expense of the contaminants. Dilutions of 1–10,000; 1–100,000 and 1–1,000,000 were inoculated in triplicate to freshly boiled Durham tubes of lactose broth. Cultures were selected and stained repeatedly for purity, and checked for aerobic contamination by agar and broth

inoculation, and 2 strains were finally selected which were unquestionably pure. These strains were then inoculated in duplicate for cultural and morphologic characteristics.

## MORPHOLOGY

The organism is a slender bacillus, of tetanus-like proportions, about 0.6 by 6 to 8 $\mu$, and Gram-negative by stain from every medium in which it has been successfully cultivated. Spores have not yet been certainly observed, nor has their presence been indicated by any detectable degree of heat resistance. The bacilli occur chiefly singly and in pairs, with occasional continuous thread forms. Motility is active in the broth from egg-meat tubes at 24 hours, and from actively growing cultures in fermentable carbohydrate broth within the first 24 hours; after that time motility ceases, probably due to excess acidity. After 48 hours in lactose broth the bacilli become vacuolate, stain irregularly, and subcultures on the third day quite uniformly fail to grow. Flagellar stain by Gray's method show numerous peritrichous flagella (at least 12 to 15).

## CULTURAL REACTIONS

Growth in egg-meat is abundant, though the supernatant broth remains practically clear; bubbles of gas appear at 24 hours; meat unchanged in color after 40 days incubation; evidently non-proteolytic; no tyrosine crystals.

In milk there is no change in reaction, no peptonization nor reduction, and growth is very sparse. Stains from milk show but few bacilli which are mostly swollen and vacuolate. In view of the activity of the organism in lactose broth this inactivity in milk seems peculiar.

Deep nutrient agar, dextrose, lactose, saccharose and casein-digest agar with and without carbohydrates,—no trace of growth.

Deep whole egg,—no change, and very slight growth evident by microscopic examination of cultures.

Deep coagulated serum,—same; no proteolysis.

Egg cube in casein-digest broth (pH 7.2),—little evidence of growth; no proteolysis.

Indol and nitrite,—no growth in these media under vaseline; routine test was negative, but meaningless in the absence of demonstrable growth.

Anaerobic plain and dextrose agar slants by Wright's and Buchner's method,—no growth perceptible, (control cultures of *Cl. botulinum* B. positive).

*Gelatin.*—as described above, at pH 7.6 colonies perceptible at 6 days at room temperature, reaching maximum size at 11 days; at pH 6.0 colonies perceptible at 3 days and of maximum size of slightly over 1 mm. at 8 days; dense spherical with slight wooly periphery. Gelatin is not liquefied at 40 days.

Pathogenicity,—negative by intraperitoneal inoculation of a young guinea pig with 1 cc. of a 48 hour egg-meat culture. Hall (1) also reports negative results on guinea pigs inoculated with sub-culture of one strain. (He also failed to observe spores.)

Fermentation reactions,—were tested first in sugar-free serum water plus 1 per cent of the sugars, etc., under vaseline seal. They were then repeated

in casein-digest broth plus sugars. Brom-cresol-purple indicator was added, and the medium was tubed in 13 by 100 mm. tubes and autoclaved for 10 minutes at 12 pounds pressure. Incubation of these tubes for 48 hours did not reveal any contaminating growth. Inoculation was made with sterile Pasteur pipets from a 24 hour egg-meat broth culture through the vaseline seal, each tube receiving about 0.1 cc. of the inoculum. Cultures were incubated at 37°C. and read daily for 7 days. When fermentation occurred it was in most cases active within 36 hours, with an abundance of gas which, in some instances pushed the vaseline up into the cotton plug. In a few of the polysaccharides fermentation was slower in developing, with only slight gas formation, while in others only doubtful trace of hydrolysis was evidenced by a slight change in indicator color with no trace of gas. Inasmuch as the typical fermentation was very active, these slight and doubtful reactions are recorded below in table 1 as negative or only plus-minus.

Together with the reactions of our organism we record those of a number of the common anaerobes as given by Levine (2) from the Special Report of the Medical Research Committee of England and with those of an anaerobe from water reported by Raab (3), and checked by us from cultures kindly furnished by him for comparison with our strains.

## DISCUSSION

The question of presence and significance of anaerobes in water supplies is usually passed over in the literature with a general statement that *Cl. welchii* and *Cl. sporogenes* are commonly present in sewage contaminated water. However, unless isolated and identified, these general statements are meaningless. In spite of frequent passing references to positive presemptive tests which fail of confirmation on Endo's or eosin-methylene-blue agar, but little attention seems to have been paid to specific identification of these anaerobes. In view of the difficulty of isolation, especially of the strains reported by Raab, as well as the one we report here, this is not surprising.

Creel (4) describes and discusses two types of anaerobes isolated from drinking water. Raab's culture, isolated from the Minneapolis city water closely resembles Creel's "Group A." We felt that our strain was quite probably identical with Raab's cultures, but, in spite of the similarity of the fermentative reactions, several differences are evident. We found the Gram-positive spores which he describes abundant in cultures of his strains, while our culture has never displayed any. His organisms are considerably thicker, and in general more massive, in contrast to our very slender organism.

TABLE 1

*The fermentative reactions of the Williamson, the Minneapolis and other common anaerobe strains*

| | GLUCOSE | LEVULOSE | GALACTOSE | MALTOSE | SACCHAROSE | MANNITOL | GLYCEROL | DULCITOL | SALICIN | STARCH | INULIN | RAFFINOSE | XYLOSE | LACTOSE BILE | LACTOSE | ARABINOSE | ADONITOL | DEXTRIN | ERYTHRITOL | GLYCOGEN | INOSITOL | LYXOSE | MANNOSE | MELEZITOSE | PERSEITOL | RHAMNOSE | SORBITOL | TREHALOSE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cl. welchii | + | + | + | + | + | − | ± | − | − | + | ± | | | | + | | | | | | | | | | | | | |
| Cl. oedematis | + | + | + | + | − | − | − | − | + | | − | | | | + | | | | | | | | | | | | | |
| Cl. chauvoei | + | + | + | + | + | − | − | − | − | | − | | | | + | | | | | | | | | | | | | |
| Cl. aerofoetidum | + | + | + | + | − | − | − | − | + | − | − | | | | + | | | | | | | | | | | | | |
| Cl. butyricum | + | | | + | + | − | − | − | − | + | − | | | | + | | | | | | | | | | | | | |
| Cl. multifermentans | + | | | + | + | − | + | − | + | + | + | | | | + | | | | | | | | | | | | | |
| Cl. tertium | + | + | + | + | + | + | − | − | + | + | − | | | | + | | | | | | | | | | | | | |
| Cl. sphenoides | + | + | + | + | ± | ± | − | − | + | ± | − | | | | + | | | | | | | | | | | | | |
| Minneapolis organism | + | + | + | + | + | + | − | + | + | + | + | + | + | − | + | ++ | − | ++ | − | − | − | ++ | ++ | − | − | − | ++ | ++ |
| Williamson organism | ++ | ++ | ++ | ++ | ++ | − | − | − | ++ | ++ | − | +± | ++ | | ++ | ++ | − | ±± | − | − | − | ++ | ++ | − | − | ±± | − | ++ |

Note: ++ means acid and gas; +± means acid with gas little or doubtful.

We have attempted, with the assistance of Hall (1), to identify this organism without success up to the present time. It fails to conform to any recognized or reported type, and is apparently a newly described organism representing one of a group of forms reported by Creel and Raab. Its significance in water supplies, as well as its source, rêmains undetermined. Apparently it is a harmless form, but its presence and reaction in the presumptive test for *B. coli* is greatly inconveniencing, since it seems to run in "epidemics" for weeks at a time.

Its relation to the "air-binding" of filter beds is an interesting problem which we expect to undertake. It is not improbable that the beds become seeded with the organisms and serve as the continued source of the difficulty.

## REFERENCES

(1) HALL, I. C.: Personal communication.
(2) LEVINE, M.: Iowa State College, Engineering Exper. Sta. Bull. 62; (1921) 20; p. 93.
(3) RAAB, F.: Jour. Amer. Water Works Assoc.; (1923) 10; p. 1055.
(4) CREEL, R. H.: U. S. Hyg. Lab. Bul. 100; (1914).

# REPORT OF COMMITTEE NO. 1 ON STANDARD METHODS OF WATER ANALYSIS[1]

Your Committee No. 1, on Standard Methods of Water Analysis, begs to submit the following report of its work during the year ending June, 1929. The activities of Committee No. 1 have followed in a somewhat general way the plans outlined in the report presented at San Francisco in June, 1928. Certain studies have been made which have related to subjects which have come up during the year. The personnel remains the same as at the time of the preceding report. The activity of the Committee in several lines has not been as great during this year as during the year preceding. This has been due in part to doubt as to the procedure which the newly appointed Committee on Water Works Practice would desire. The activity required of several of the members, including the Chairman, in connection with their regular vocations, has also been responsible for some reduction in work.

During the coming year it will be necessary to face a considerably greater work than during this year, as it is proposed by the American Public Health Association, joint partner of the American Water Works Association in the publication of Standard Methods of Water Analysis, that a new edition of that publication shall be issued as soon as possible after the meeting of the American Public Health Association in Minneapolis, Minnesota, September 30 to October 5, 1929. It will be necessary that the more important changes to be made in the forthcoming edition of Standard Methods shall be fairly well under consideration by the time of the meeting of the American Public Health Association this fall. Committee No. 1 has already commenced to prepare such material. Actual publication will probably take place in 1931 or 1932.

A statement of the assignments and the progress of work under the referees of Committee No. 1 is given below.

[1] Presented before the Toronto Convention, June 24, 1929. Approved by The Committee on Water Works Practice.

BACTERIOLOGICAL METHODS

*The composition of brilliant green lactose bile medium and other media studies, H. G. Dunham, Referee*

Comparatively little work has been done during the current year on the use of brilliant green lactose peptone bile medium, except in the form of routine studies of the application of this medium which have been continued in a number of laboratories, including those of Mr. Wallace, of the Detroit Board of Water Commissioners, the laboratory under the control of Mr. Harry E. Jordan, of the Indianapolis Water Company, in the laboratory of which the Chairman is Chief at the University of Iowa, and in a number of other localities.

During this year Mr. Dunham has continued his study of the medium suggested by Dr. A. J. Salle, of the University of California, and described by Dr. Salle in the *Journal of Infectious Diseases*, Volume 41, Page 1, 1927, under the title of "Agar-Dye Differential Medium for the Colon Typhoid Group." Mr. Dunham has also made preliminary studies on a number of other types of media, including the following:

"A Culture Medium for Differentiating Typhoid-Colon-Aerogenes Groups and for Isolation of Certain Fungi," J. S. Simmons, Journal of Infectious Diseases, Volume 39, Page 209-214 (1926).

"Isolation of B. typhosus from Sewage and Shell Fish," Dr. W. James Wilson, British Medical Journal, Volume 1, Pages 10061-10062 (July 23, 1928).

"Use of a Glucose Bismuth Sulfite Iron Medium for the Isolation of B. typhosus and B. proteus," W. James Wilson and E. M. McV. Blair, Journal of Hygiene, Volume 26, Pages 374-391 (October 1927).

"The Correlation Between Differential Tests for Colon Bacteria and Sanitary Quality of Water," I. M. Lewis and E. C. Pittman, Journal American Water Works Association, Volume 19, Pages 78-92 (1928).

"Precipitation of Iron Compounds from Salts of Organic Acids by Some Species of Eubacteriales," I. M. Lewis, Centrallblatt für Bakteriologie, Abteilung II, Volume 75, Pages 45-52 (July 2, 1928).

Mr. Dunham has also assisted in a preliminary study of a medium developed by Mr. Carl J. Lauter, of the Dalecarlia Filtration Plant at Washington, D. C. The paper on this subject by John F. Dominick and Mr. Lauter, as yet unpublished, has been circulated through the membership of Committee No. 1 and it is hoped that some investigations of value are under way. Mr. Lauter's medium is a broth

medium which is based somewhat on the composition of the Salle agar medium.

Mr. Dunham has also assisted in the study of the medium for the direct enumeration of organisms of the colon aerogenes sections as worked out by Mr. R. E. Noble, of the Chicago Board of Health. This medium was described by its author in the paper entitled "Cyanide Citrate Pour Plate Method for Direct Determination of the Colon-Aerogenes Content of Water and Sewage," Journal of the American Water Works Association, Volume 19, Page 182 (1928). The author has continued his attempt to simplify the procedure of the use of his medium during the current year. Mr. Dunham has assisted him especially in the attempt to find out what type of preparation would yield the most satisfactory agar for the medium. Various types of washing processes were carried out in coöperation with Mr. Noble. It is hoped that further simplification of the procedure and more information concerning the agar to be employed may result in making Mr. Noble's procedure of more general application.

*Non-confirming spore formers and their significance in water examination, Norman J. Howard and John F. Norton, Referees*

Mr. Howard has been so much occupied with his investigation on superchlorination and dechlorination that he has not had much time to devote to the consideration of the importance of the spore forming bacteria which interfere with the presumptive test for the organisms of the colon aerogenes group. Dr. Norton has devoted his attention primarily to the test for organisms of a different sort, namely the streptococci. The importance of these organisms in connection with water supply and sewage has been pointed out from time to time in past years. Dr. Norton's particular interest in these organisms at this time, however, lies in the direction of the investigation of the sanitary quality of swimming pool waters. In his capacity as editor of the American Public Health Association for Standard Methods of Water Analysis, Dr. Norton is enabled to keep the members of Committee No. 1 closely in touch with developments suggested by the referees of that Association, particularly the referee on bacteriological methods, C. T. Butterfield, who is not a member of the American Water Works Association at the present time. The referee on chemical methods, Dr. A. M. Buswell, is a member of Committee No. 1 of the American Water Works Association.

*The use of brilliant green lactose peptone bile and other tri phenyl methane dyes as secondary fermentation media in the determination of the bacterium coli group, Harry E. Jordan, Referee*

Mr. Jordan has not carried on work on his general assignment with the activity of the last two years. The reason is that the work assigned to Mr. Jordan has largely been completed. At present the main object to be desired is further wide experience with the secondary methods of the use of brilliant green lactose peptone bile as suggested by Mr. Jordan in the last report of this Committee. It seems probable that the use of this method as a secondary method will become optional when the new edition of Standard Methods is produced. Information at hand at present is sufficient to warrant such a general conclusion.

Mr. Neil Kershaw, in the laboratory under Mr. Jordan's control, has investigated the possibilities of making a quantitative test out of the para nitrobenzeneazoresorcinol method suggested by Dr. William L. Ruigh, of the Department of Chemistry of Princeton University. Dr. Ruigh's description of his method appears in the *Journal of the American Chemical Society*, Volume 51, Number 5, Pages 1456–1457 (May, 1929) under the title of "A Sensitive Test for Magnesium." Dr. Ruigh apparently intended the procedure simply as a qualitative test. Mr. Kershaw's conclusions are that the colors as at present produced may be quite deeply blue, but they are not stable. A drop of the 0.5 percent solution of the reagent in 1 percent sodium hydroxide added to the extent of 1 drop in 100 ml. of tap water containing approximately 25 parts per million of magnesium, produced a very deep color. The fading of the color in as short a time as five to ten minutes, however, makes the application of the test very difficult. It is hoped that a method will be found to make the color more permanent. The test seemed to be sensitive to about one-quarter of a milligram of magnesium in 100 milliliters of the sample under the conditions used by Mr. Kershaw. It is hoped that further studies may indicate that the method is more useful than the first indication would lead one to believe. If the difficulty with the fading can be eliminated the usefulness of the method will naturally be very materially extended.

*The use of eosine methylene blue agar and modifications in the confirmation of organisms of the colon group, Max Levine, Referee*

Conditions in the department with which Dr. Levine is connected have made it necessary for him to do very little laboratory work on

his assignment during the current year. His general familiarity with the field of the colon-aerogenes group makes his advice in other lines very valuable to the Committee. During the coming year Dr. Levine hopes to study further the application of various recently proposed differential media in the examination of organisms of the colon group taken from eggs and from sewage, as well as from osyters. Dr. Levine is handicapped in his routine work by the fact that the local water supply in his community is derived from wells and therefore polluted surface waters undergoing treatment are not available as a rule for continuous study and experimentation.

*The use of brilliant green lactose peptone bile as a primary medium in the detection of organisms of the colon group, MacHarvey McCrady, Referee*

The work on this subject, like that under the control of Mr. Jordan, has largely been concluded. During the current year Mr. McCrady has interested himself in an attempt to determine urea in water and sewages. The method which he proposes involves the use of urease, an enzyme, by means of which urea is converted quickly into ammonium carbonate. Preliminary investigations by Mr. McCrady have not shown under his conditions that urea was very rapidly hydrolyzed by the boiling with a small amount of sodium carbonate as in the usual method applied for the determination of ammonia nitrogen. The material to be examined is placed in a flask, 1 ml. of $\frac{N}{10}$ sodium carbonate is added and the liquid is boiled rapidly down to about half the volume. Ammonia nitrogen is given off. One milliliter of hydrochloric acid is then added to the flask and the boiling is continued down to 50 ml. The liquid is cooled and a small amount of urease solution of known ammonia content is added. The mixture is incubated at 50° to 55°C. for an hour and a half. This allows the hydrolysis of the urea. The residue in the flask is then diluted with ammonia-free distilled water and the ammonia resulting from the hydrolysis of the urea is then driven off and estimated by the usual Nesslerization process. Readings are obtained in terms of nitrogen, but may readily be calculated to urea if required. The full details of Mr. McCrady's process for the determination of urea have been supplied to members of Committee No. 1 and are under consideration by them at this moment.

## CHEMICAL METHODS

*The determination of turbidity and coefficient of settling, John R. Baylis, Referee*

In the course of his work during the current year, Mr. Baylis has prepared a proposed revision of the existing method for the determination of turbidity, basing all turbidity measurements on the values obtained from the Jackson turbidimeter. Turbidity readings by instruments of greater delicacy than the Jackson turbidimeters, with long tubes, as for example the Baylis and Graf turbidimeters, are referred in each case to the results obtained with more concentrated turbitities by the use of the Jackson method.

An interesting summary of European practice in regard to the determination of turbidity will be found in an article entitled "Les Qualités Organoleptique de l'Eau: Limpidité, Couleur" by M. Guillard, Chef Adjoint du Service de Surveillance des Eaux d'Alimentation de Paris, Annales de Hygiene, Volume 4, (new series) 449–496 (August, 1928).

Mr. Baylis has also prepared during the year a paper entitled "Significance and Methods for Determination of Filter Plant Turbidity." This paper was read at the Kansas Water Works Operators' School in February, 1929 and has been published in a number of places, including the magazine Water Works Engineering, under the title, "Watch Your Water Supply's Turbidity." The reference to this article is Water Works Engineering, Volume 82, Number 9, Pages 525–526, 550 and 553 (April 24, 1929). The paper was also published under its original title in Municipal News and Water Works, Volume 76, Number 4, Pages 156–159 (April, 1929).

Mr. Baylis has also continued his work on the determination of phenols. He has coöperated with Mr. Emery J. Theriault and with Dr. Boruff, referee of Committee No. 1, in connection with this matter. Mr. Theriault has recently published a summary of the situation regarding the determination of phenols. This article appeared in the Journal of Industrial and Engineering Chemistry, Volume 21, Number 4, Pages 343–6 (April, 1929), under the title "Chemical Aspects of Stream Pollution by Phenols."

*The mineral analysis of water, R. C. Bardwell, Referee*

Mr. Bardwell has continued to devote his time during the current year in trying to maintain a close liason with Sub-Committee No. 8

of the General Committee No. 19 on Boiler Feed Water Studies of which he is a member, under the Chairmanship of Mr. S. T. Powell.

The Sub-Committee No. 8, under the Chairmanship of Mr. Harold Farmer, is giving consideration to the analysis of water for steam boiler purposes, with particular reference to the preparation and adoption of standards which may be classified as referee methods. Study is being given to the present method in use for determining dissolved oxygen and a recommendation is being made for a tentative method for the determination of dissolved oxygen in "Pure or Distilled" water for boiler feed which also has been approved by the Chemists' Committee of the National Electric Light Association. The method is practically the same as the original Winkler Method without the Rideal-Stewart modification. Manganous chloride is used instead of manganous sulphate as recommended in the current edition of Standard Methods of Water Analysis.

Sub-Committee No. 8, under Mr. Farmer's direction, is also preparing to recommend standard methods for "Sampling Streams, Rivers and Lakes." The work on free $CO_2$ is not sufficiently far advanced to report definite recommendations.

Further consideration and tests have been continued in connection with rapid method of mineral analysis of water for boiler purposes in accordance with recommended procedure published in the Journal of the American Water Works Association, August, 1925. Results have been reported satisfactory and no criticism or further suggestions have been received by the referee. It is again recommended by the referee that the published procedure be adopted, at least as a tentative standard, in the examination and control of water for railway boiler purposes and small steam supplies.

Mr. Bardwell has also given some consideration to the methods of determination of sodium, magnesium, and calcium which have been submitted to the office of the Chairman of the Committee. He has also considered the periodate and orthotolidine methods for manganese which have been suggested by Mr. Forman, of the New Jersey State Department of Health. Further reference will be made to these methods under the report of the Chairman.

*The detection of phenols, C. S. Boruff, Referee*

During the past year the referee has been unable to give time to laboratory investigations on the determination of small quantities of phenols. He has, however, tried to keep in touch with the work through correspondence and papers offered for publication.

Mr. Louis Shnidman, of the Rochester Gas and Electric Corporation, Rochester, New York, has carried on some very interesting phenolic investigations. In all his studies he used a modified form of the Folin-Denis method. He treats his sample with silver lactate and then the filtrate from this is treated with sodium chloride in order to remove the proteins and the major portion of the organic material present. It is known that these things are among the numerous substances that interfere with any phosphotungstic-phosphomolybdic used in the determination of phenols. Mr. Shnidman has devised methods for the determination of "free" and "total phenol" concentrations.

Of all the methods available for the quantitative determinations of small quantities of phenols, the various modifications of the Gibbs 2.6 dibromoquinonechlorimide method seem to be the most satisfactory. The Baylis modification as reported in the Journal of the American Water Works Association, Volume 19, 597 (1928), has been used with success by many. It is very exacting in its manipulation but is considered to be reliable. Dr. F. W. Mohlman, of the Chicago Sanitary District, has used this method in his studies on The Biochemical Oxidation of Phenolic Wastes, (Am. J. Public Health *19*, 145–157 (1929). Mr. E. J. Theriault, of the United States Public Health Service, has also used the Gibbs-Baylis method in his studies on "The Chemical Aspect of Stream Pollution by Phenols," Journal of Industrial and Engineering Chemistry, *21*, 343–6 (1929). The latter investigator has also introduced some valuable modifications. Instead of concentrating the phenolic compounds by distillation he finds it easier to make the solution distinctly alkaline with sodium hydroxide so as to convert the phenol to sodium phenolate, then to evaporate off any desired amount. He then recommends neutralization of the alkali with an acid and the distillation of the phenol from the concentrated solution. Mr. Theriault also makes an alcoholic solution of the 2.6 dibromoquinonechlorimide, and finds that this solution will keep several days instead of but a few minutes as does an aqueous solution. Mr. Theriault gives in the above mentioned paper a good discussion of the phenol test, its use, necessary precautions and its limitations. In a letter to the referee he writes as follows:

"The Gibbs method, at best, is not an easy procedure, although it is capable of yielding accurate results. I believe that it should be included in Standard Methods."

*The determination of free chlorine, A. M. Buswell, Referee*

In connection with Dr. Buswell's function as chemical referee of the American Public Health Association on Standard Methods of Water Analysis, Dr. Buswell and the Chairman of the Committee have conducted extensive correspondence. Considerable time has been devoted in Dr. Buswell's laboratory to a determination of soluble silica. (This work was reported in the article: "Occurrence of Silica in Natural Waters," O. W. Rees. Industrial and Engineering Chemistry, Analytical Edition, *1*, Number 4,200–1, October 15, 1929.) (Note: This article appeared after our report was read.)

He has also arranged for the investigation of the procedure for the determination of manganese by the periodate and the orthotolidine method and for the determination of sodium by the Kolthoff and Barber method, Journal of the American Chemical Society, June, 1928, later to be described in the report of the Chairman. An article entitled "Changes of Sulphur Compounds During Sewage Treatment" by A. L. Elder and A. M. Buswell has been published in Industrial and Engineering Chemistry, Volume 21, pages 260–252 (June, 1929). This article deals with a method for determining hydrogen sulfide and the alkaline and insoluble sulfide sulfur. It does not distinguish among volatile and non-volatile and insoluble sulfides. Dr. Buswell has arranged for some additional investigational work on the determination of hydrogen sulfide to be carried out through one of his former assistants, Dr. A. L. Elder, now at Oberlin College. Dr. Buswell's work in connection with the revision of the procedures in the forthcoming edition of Standard Methods of Water Analysis will be quite extensive. He has also conducted a considerable amount of research work for the Committee.

*The determination of iodine in water, Dale L. Maffitt, Referee*

Most of the work done during the past year by the referee's laboratory on the determination of iodine in water has been with the McClendon procedure as described in the report of 1927, as this method is believed by the referee to be best suited for water analysis. The procedure has used raw river, lake, deep well and shallow well water for samples, and satisfactory results with each have been secured.

In the February, 1929 issue of Industrial and Engineering Chemistry is advertised a vitreosil combustion tube designed by Dr. McClendon which could be used in the place of the Pyrex tube recom-

mended in the 1927 report, especially where facilities for bending Pyrex tubing are not at hand. This tube is offered for sale by The Thermal Syndicate, Ltd., Brooklyn, New York.

Until a new procedure is described with some decided advantage, such as for instance the elimination of the necessity of evaporating large amounts of sample, the referee would recommend the above McClendon method.

The referee has also assisted in the comparison of the determination of manganese by the periodate and orthotolidine procedures.

*The determination of biochemical oxygen demand, F. W. Mohlmann, Referee*

There has been some interest in the past year in a study of methods for the determination of biochemical oxygen demand by the direct method, in order to obviate the necessity for dilution, with its attending inaccuracies. The first work done toward this end in recent years (excluding the work of Adeney and Rideal) was reported by Sierp in 1927 (*Technisches Gemeindeblatt, 30,* 179–181, September 20, 1927). (See also "A new method of determining biochemical oxygen demand," F. Sierp, Industrial and Engineering Chemistry, 20, 247, March, 1928.) The Sierp method has been tested out in a number of laboratories in the United States. A report of some of the work is given in proceedings of the Fourteenth Annual Meeting of the New Jersey Sewage Works Association, Pages 52–55, March 22, 1929. Dr. Rudolfs reports comparative studies in laboratories at Baltimore, Schenectady, Trenton, and New Brunswick. The results are somewhat conflicting and lead to no very definite conclusion except that the tendency seems to be toward lower results by the direct method. Another report of a comparison by Dr. Rudolfs is given in Technical Publication No. 104, Wallace & Tierman, Inc., Page 18, (1929).

A number of comparative runs up to twenty days in the laboratories of the Sanitary District of Chicago gave results by the dilution method which seemed to be somewhat lower than those by the Sierp method.

Studies made by Dr. Buswell and G. E. Simons indicated a fairly close check between the two methods (Industrial and Engineering Chemistry, Analytical Edition, *1,* 214–5, (October 15, 1929)).

A recent paper by E. J. Theriault and C. E. Butterfield describes a rather complicated piece of apparatus for determination by the

direct method (U. S. P. H. S. Public Health Reports, *44*, 2256–7, (September, 20, 1929)).

As a result of the work done in other laboratories with the Sierp apparatus, the general conclusion seems to be that the direct method is not suitable for routine plant results or under conditions where a large number of determinations are required. The use of the direct method may be of value in research or special studies of sludge or other material having a very high oxygen demand.

It is unlikely that the dilution method will be supplanted by the direct method. The dilution method required further studies of technique, diluting water and bacterial phases. Investigations of synthetic diluting waters are being made in a number of laboratories. Some of the simpler of these synthetic waters contain 60 p.p.m. potassium bicarbonate (Sanitary District of Chicago). More complex synthetic waters have been used by Greenfield, Elder and MacMurray, and Theriault. Comparative tests using various waters have been made in the laboratories of the United States Public Health Service. No conclusions have as yet been published regarding the most satisfactory type of synthetic waters.

For the present, it is recommended that further work be done on the dilution method, inasmuch as it is unlikely that the direct method can be adapted for routine work.

The bacteriological work carried out in the laboratories of the Chicago Sanitary District on the use of brilliant green lactose peptone bile and the Lauter-Dominick broth was reported for Dr. Mohlman by Mr. Ruchoft, bacteriologist of the Chicago Sanitary District Laboratories.

## MICROSCOPICAL METHODS

*Microscopical examination of water (plankton), W. F. Langelier, Referee*

The referee has devised and used two wire cloth plankton nets during this year. These nets are more convenient to use and, as predicted by the referee, have a lower net factor. Improvement in the wire cloth net is expected. It is especially desired to eliminate the use of solder, probably substituting a water proof cement.

In his investigations on the determination of hydrogen sulfide the referee has found that there is a need for a more comprehensive and dependable method, especially for sewage work in the field, where sulfide tests are of value in estimating and controlling odor nuisances.

The present method is inadequate and wholly worthless for the purpose. The referee finds that the procedure developed by Enslow (mimeograph sheets dated March, 1929) is much better. A method using antimony and potassium tartrate (tartar emetic) recently developed by A. J. Salle and E. A. Reinke, of the California State Department of Health, offers still greater promise. This method will be published in the California Sewage Works Journal.

In the examination of water and sewage it is the referee's opinion that total, fixed and volatile sulfides should be determined. Both the Enslow method and the Salle-Reinke method attempt to do this. The Enslow method might perhaps better be called a determination of the "iodine demand" or "iodine consumption" of a fixed and volatile nature. The color of antimony sulfide produced in the Salle-Reinke test, however, is a specific test for the sulfide ion and therefore iodine-consuming substances, other than sulfides, cannot interfere. The referee hopes to conduct comparative tests on the Enslow and Salle-Reinke methods during the coming year.

*The field representatives, Lewis I. Birdsall, Linn H. Enslow, Sheppard T. Powell*

Mr. Birdsall has taken on new duties in the company by which he is employed and as a result he is unable to travel over the country with the frequency which he formerly did. Mr. Birdsall has asked to be released from his Committee assignment. Dr. William U. Gallaher has been selected to succeed Mr. Birdsall on this work and his selection has recently been approved by the Chairman of the Committee on Water Works Practice. Dr. Gallaher will begin his work immediately after the submitting of this report.

Mr. Linn H. Enslow has been very active during the current year in putting the Chairman of the Committee into touch with a series of problems and in securing assistance by laboratory workers outside of the Committee membership. Information collected by Mr. Enslow has covered such diverse fields as the proposed determination of chlorine demand; starch-iodide vs. orthotolidine in tests for residual chlorine; determinations of hydrogen sulfide; and colorimetric manganese determinations. He has also reported on various factors affecting the residual chlorine determination. Among other matters of importance, the influence of nitrites on the orthotolidine test at Beverly Hills, California, and at Miami, Florida, have been called to the attention of the Committee. In connection with the ortho-

tolidine test, Mr. Enslow has given the following requirements in addition to those commonly kept in mind:

1. The orthotolidine solution should contain, roughly 18 percent of fresh concentrated hydrochloric acid by volume.
2. In alkaline waters or highly organic liquid, the ratio of 2 ml. of reagent to 100 ml. of sample should be employed.
3. If the sample is below 15°C. (59°F.) the temperature should be raised to about 15°C. before adding the orthotolidine reagent.
4. The time of reaction between addition of orthotolidine followed by thorough mixing and recording the color should not exceed three minutes and in most cases one minute is ample.
5. Color increase after five minutes, which, if it does not appear earlier, should not be recorded as available chlorine except in some special cases where chloro-organic derivatives may possess some significance. Occasionally such may be the case in sewage chlorination.
6. The comparator method employed in making the orthotolidine test embodies the most desirable features and compensates for the errors caused by practically all of the commonly involved factors. Reference: The True Free and Apparently Free Chlorine in Solution and its Detection, by Karl Bauer, Franz Noziczka and Otto Stüber, Vom Wasser, ein Jahruch, für Wasserchemie and Wasserreinigungstechnik, Volume 2: (1928); Review in the New Books List, Journal, American Water Works Association, April, 1929, Page 586.

In connection with studies on settleable solids in various parts of the country, Mr. Enslow has advised that according to his investigation in such cases the Imhoff cone for determining solids by volume is the most commonly used equipment. Usually the two-hour settling period recommended by Dr. Imhoff is followed and the sides of the cone are not scraped down. Mr. E. A. Reinke (California Sewage Works Journal, Number 1, 112 (1928)) prefers a one hour period of sedimentation, releasing solids clinging to the walls of the Imhoff cone after 15 minutes by tapping or gently stirring the contents of the vessel. He advises keeping cones filled with water between tests and occasional washing with kerosene or gasoline to remove grease from cone walls. Mr. Tiedeman, at Huntington, Long Island, had adopted the procedure of slightly rotating the cone

between the hands in order to loosen adherent solids and thus he materially increases the reading. Such a procedure as that employed by Tiedeman should be made standard or else discarded and the plain settling agreed upon. The rotation scheme, or other method of dislodging the solids from the walls of the settling cone, would seem to give results of greater accuracy and more nearly to approximate the amount of settling in sewage tanks.

Settleable solids are also determined gravimetrically in a number of localities. The procedure followed is usually quite like the usual determination for suspended solids. A Gooch or Alundum crucible is used for this work. Total suspended solids are taken on the fresh or shaken sample and later a portion of the supernatant liquid is removed by a pipette, decanted or syphoned, from a specimen of sewage which has been allowed to settle in a glass beaker for one or two hours. The difference between the results of the shaken sample and on the settled sample, of course, are taken to give the settleable solids by weight. On account of the much lessened amount of suspended solids in the settled sample it is customary to take a much larger specimen for filtration through the Gooch crucible or the alundum crucible, whichever is used. The solids are dried at from 100° to 110°C. to constant weight. It is desirable also to attempt to decide whether settleable solids by weight or settleable solids by volume is the more desirable determination. While it may be expected that a factor for the relationship between the two would vary from time to time and with locality, it might be worth while to attempt to evaluate such a factor in several localities. Attention is called to the fact that the temperature which has been selected for the drying of the residue in the determination of residue on evaporation for water samples is 180°C.

In connection with the determination of manganese, Mr. Enslow was instrumental in putting the Committee in touch with the work of Mr. LeRoy Forman, of the New Jersey State Department of Health, who was engaged in studying the use of the orthotolidine method for determining manganese. He also secured the coöperation of Mr. Edward S. Hopkins, Principal Sanitary Chemist of the Bureau of Water Supply of the City of Baltimore, and Dr. F. E. Hale, Director of the Mount Prospect Laboratories of New York City in comparing results of Mr. Forman's method.

Mr. S. T. Powell, our Field Representative, who is also Chairman of the Joint Committee on Boiler Feed Water Studies, has been able

to keep our Committee closely in touch with the work undertaken by a large group of men associated with the work on boiler feed waters. At the request of the Chairman of the Committee he has made arrangements to have the method for the determination of small amounts of dissolved oxygen described by F. W. McCrumb and W. R. Tenney in the Journal of the American Water Works Association, Volume 21, Page 400 (March, 1929) tried out in connection with boiler feed water work. Mr. Powell's sub-group on such work under the control of Mr. Harold Farmer, of Philadelphia, has already given considerable thought to the use of the Winkler method for dissolved oxygen under such conditions.

THE WORK OF THE OFFICE OF THE CHAIRMAN OF THE COMMITTEE ON STANDARD METHODS FOR THE EXAMINATION OF WATER (COMMITTEE NO. 1)

The work carried out by the Chairman of Committee No. 1 has included the usual extensive correspondence which is associated with work of this character. Attention of the various referees has been repeatedly called to new developments or possible improvements in work along their lines which have been carried out in other localities. Constant watch has been kept over abstract material and miscellaneous periodicals in the hope of securing information which would be useful to various members of the group. On several occasions advance information prior to publication has been possible. Data on silica tests, hydrogen sulfide, the proposed Ruigh method for magnesium, the proposed Lauter-Dominick broth, the periodate and orthotolidine methods for the determination of magnesium, the Kolthoff-Barber method for the determination of sodium, and a number of other subjects have been called to the attention of the entire group. Frequently copies of the papers or procedures have been supplied.

Investigations on the determination of cyanides in water and sewage have been continued in the office of the Chairman of the Committee and also determinations of the reliability of brilliant green lactose peptone bile in the examination for organisms of the colon-aerogenes group have been carried out as a part of the chairman's work. A small number of preliminary tests have been made upon the Lauter-Dominick broth and on the Lewis and Pittman medium for the detection of organisms of the aerogenes type.

## RECOMMENDATIONS

Your Committee No. 1 would respectfully submit the following recomendations with regard to the continuation of its work along the general lines of endeavor which it has followed during past years:

1. The various members of the Committee should be authorized to give special attention during the year to the form of presentation of the directions for the various tests employed in water and sewage examination now contained in Standard Methods of Water Analysis. It is very important in connection with the proposed revision of the procedures that all ambiguities and irregularities in the material should be removed. Procedures for new optional or provisional methods should be included in the forthcoming book.

2. The studies on methods of testing for members of the colon group of bacteria, including the investigation of so-called differential media, should be continued along such lines as seem to offer prospects of useful information.

3. The studies of the enumeration of the organisms of the colon-aerogenes group should be further considered with the object of establishing the Phelps colon index, the McCrady probability system, or some other, as an official approximation procedure in estimating the number of colon organisms present in a definite volume of the water under examination. Such a method should be reasonably accurate and not too complicated for general use. Tables, such as were originally provided by McCrady, might well be calculated for different numbers of tubes planted with varying quantities of water according to the preferences of the laboratories.

4. The study of non-confirming spore-forming lactose fermenting organisms should be continued and the significance of organisms of this type should be carefully considered. Symbiosis, or synergism, and antibiosis, as well as the matter of over-growth on so-called differential medium, should receive attention in connection with this matter.

5. Studies concerning procedures for the detection of streptococci should be made, and special attention should be given to easy procedures for the rapid detection of these organisms in the water of swimming pools.

6. Close liason should be maintained in coöperation with Sub-Committee No. 8 on the Analysis of Boiler Water under the Chairmanship of Mr. Harold Farmer, of the Philadelphia Electric Com-

pany. Liason established through Mr. Sheppard T. Powell, Field Representative of Committee No. 1, and Mr. R. C. Bardwell, Referee on rapid methods of mineral examination of water, are also considered essential in this report.

7. Additional work should be carried out on the test for free chlorine by ortho-tolidine, starch iodide, and other procedures. Special studies of the form of chlorine compounds which react with these reagents are desirable.

8. The determination of chlorine demand should receive some attention, both as to its use in the examination of ordinary water and sewage and in connection with the possible correlation of this determination with that of biochemical oxygen demand in sewages and trade wastes and perhaps with the determination of oxygen consumed.

9. The work on the determination of turbidity and coefficient of settling should be continued, with special attention to that range from 0.2 to 25 parts per million turbidity which is below the scale of the Jackson turbidimeter even when using long tubes, and above the range of the Baylis turbidimeter. The volumetric estimation of the suspended matter of water along the lines already laid down by Mr. Baylis, the referee on this subject, should receive additional investigation in other laboratories.

10. A standard method for settleable solids in sewage is desirable. If possible, a more desirable piece of apparatus than the Imhoff cone should be devised. If the cone is to be continued in use, it should be determined whether or not the two-hour sedimentation period established by Dr. Imhoff is to be continued and it should be established definitely whether or not rotating the cone between the hands for the purpose of dislodging adherent sediment is to be permitted. Studies of the relative values and values obtained in the determination of settleable solids by volume and the determination of settleable solids by weight are believed advisable.

11. The work on the determination of biochemical oxygen demand should be continued with special attention to the preparation of standard dilution water and the specifications of the details of the technique in order to avoid errors by less experienced analysts. Methods for the dilution of the sewage in making this test on concentrated wastes where minute amounts of the actual wastes are to be placed in bottles for incubation should be carefully worked out so as to avoid reaeration and to permit of maximum speed with minimum requirements as to apparatus.

12. The investigation on the determination of dissolved oxygen in water and sewage by the Winkler method should be resumed and the work on the detection and estimation of very small quantities of dissolved oxygen in boiler waters should be continued in coöperation with Mr. Farmer's Sub-Committee No. 8 on boiler water analysis. The difference of opinion as to whether manganous chloride or manganous sulfate is the more desirable salt for use in the Winkler test should be reconciled. The ortho-tolidine method for dissolved oxygen of McCrumb and Tenney should be investigated if it seems that it is worth while in boiler water work and in general practice.

13. The investigation on the determination of free carbon dioxide should be resumed. The coöperation of the Committee on Boiler Feed Water Studies should be obtained if possible.

14. The study of methods for the detection of minute amounts of phenols should be continued and extended.

15. The study of methods for the determination of hydrogen sulfide in waters and sewages should be carried out. Volatile and fixed sulfides should be estimated.

16. The study of the detection of minute amounts of cyanides in waters and sewages should be continued.

17. Further study should be given to nitrogen determination and the nitrogen factors in water and sewage examination and to so-called sewage nitrogen losses as investigated by Dr. Buswell, our referee.

18. The study of the determination of soluble and colloidal silica should be continued.

19. The determination of manganese by the periodate method of Willard and the ortho-tolidine method of Forman should be studied further.

20. The study of nitrates and nitrites in sewages and their interaction during the examination of specimens should be continued.

21. The proposed rapid mineral analysis procedure submitted by Mr. Bardwell, our referee on this subject, should be rewritten and submitted to the American Public Health Association for their reaction to the scheme, looking forward to the inclusion of this material in the Seventh Edition of Standard Methods of Water Analysis.

22. The study of the Hensen net method for the enumeration of plankton organisms should be continued, together with the attempt to develop a standard plankton net of the Hensen type, but made of

fine metallic gauze. Consideration of methods for the description of the nannoplankton and enumeration of organisms of this class should be undertaken if possible.

23. Continued search should be made for a rapid method for the detection of magnesium and calcium, preferably by colorimetric methods, which will be sufficiently accurate for purposes of ordinary mineral analyses and which will offer advantages in time and equipment to be used in the determination of calcium and magnesium in the routine of water softening plants.

24. If possible, the Barber-Kolthoff zinc uranyl acetate method for determination of sodium should be given consideration as to its general usefulness.

25. Subject to the approval of the Committee on Water Works Practice, Committee No. 1 should be authorized to include in its membership such additional referees from among the membership of the American Water Works Association as may be necessary to handle the problems listed above and any others which may need the attention of the committee during the period intervening between the Convention in June, 1929, and the Convention in the summer of 1930.

Respectfully submitted,

R. C. Bardwell
John R. Baylis
Lewis I. Birdsall
C. S. Boruff
A. M. Buswell
H. G. Dunham
Linn H. Enslow
Norman J. Howard
Harry E. Jordan
W. F. Langelier
Max Levine
Dale L. Maffitt
MacHarvey McCrady
F. W. Mohlmann
John F. Norton
Sheppard T. Powell
Jack J. Hinman, Jr., *Chairman.*

# HOW THE PRESS CAN HELP THE WATER WORKS SUPERINTENDENT[1]

By Philip Schuyler[2]

Water is the most precious of all our commodities. Without it we could neither physically exist nor materially thrive. Unfortunately, it is the least appreciated and understood. Water is just water to the majority of people and is taken for granted. If it is clear, cold, palatable and pure, it is merely what it ought to be. Does the water works superintendent get any credit for it? No. But if anything goes wrong, how quickly he is censured.

The water works superintendent holds a position of great responsibility, as he is to a large extent the 'guardian angel' over the health of every man, woman, and child in his community. Therefore, he should be accorded the distinction he deserves, and should receive a salary commensurate therewith. He should be allowed to travel and learn how water is produced, treated, and distributed in other communities. He should also be allotted a special fund for research.

Instead, the water works superintendent, except in the big cities, is expected to wear overalls all the time and be on the job night and day; is required to be everything from 'purificationist' to a pick-and-shovel laborer; and at the same time be up-to-date on the thousand-and-one angles of water works practice; and all on a salary of $150 per month.

This all can be rectified if the public is properly enlightened. It is up to each water works superintendent to educate the consumers on his system, and at the same time educate himself, so that the public will understand what water really is and appreciate the value of his services.

The water works superintendent must remember that success is based largely on good salesmanship. He has two things to sell—the 'story of water', and, himself, if he wants to make a success of his water works, and secure greater remuneration. Toward accomplishing these ends, he has at his command the smallest tool in his kit—

[1] Presented before the Pacific Northwest Section meeting, May 17, 1929.
[2] Editor, Western Construction News, San Francisco, Calif.

the pen—a tool mightier than the wrench. He should become as adept with it as he is with his other tools.

Therefore, the press—both popular and technical—can be of great help to the water works superintendent. First, through the medium of the technical periodical he can exchange ideas with superintendents in other cities, and thus rapidly increase his knowledge of water works practice; and secondly, he can take extracts from these periodicals and incorporate them in special articles to be published regularly in the local press or popular magazines, for the enlightenment and education of the consumers and public at large.

One of the best campaigns of publicity that I know of, was the series of articles published by R. H. Corey, general manager of the Coos Bay Water Company, Oregon, in the local press about four years ago and republished in "Water Works Engineering." He told the public all the facts about the water supply, its treatment, and its distribution.

The consumers and the public should be informed on the following facts:

1. *Source of Supply.* Whether it is adequate or inadequate; how soon an additional supply should be secured.

2. *Character of Water.* Whether hard or soft; its chemical analysis, and why it varies from season to season; why it is sometimes turbid and should be filtered; why it sometimes has an algae taste, and how difficult it is to prevent algae and crenothrix growths. Why a soft water is preferable to a hard one, and how much a soft water saves in the laundry, in heating systems and in boilers.

While on the subject of water, permit me to stress the fact that we know very little about water and its relation, chemically, to industry, health, and plant life. We do not know what combination of minerals in water are the best for the health of human beings and animals; or how they affect the various products of industry. We have determined only recently that the mineral characteristics of the raw-water supply have a direct bearing on sewage treatment. Undoubtedly a similar relation exists in some of the products of industry.

3. *Storage Reservoirs.* Why adequate distributing as well as storage, reservoir capacity is necessary. What the present storage consists of, and why additional storage is necessary. How the source of supply and reservoirs are protected from pollution.

4. *Distribution.* What the distribution system consists of: sizes and kinds of pipe. Why 'permanent' types of pipe of adequate

size should be laid in preference to temporary lines of small size. The necessity for complete circulation, and control by sufficient gate valves. The big reduction in fire insurance rates accorded by the Fire Underwriters to systems rating A-1.

5. *Pressures.* What pressures are maintained in the distribution system, and reasons therefore.

6. *Filtration.* Why filtration is usually necessary. What filtration does and what it costs.

7. *Chlorination.* Why chlorination is essential; how it is applied; how it works; and that a taste of chlorine in the water instead of being harmful, is an 'insurance policy' against typhoid fever and other water-borne diseases.

8. *Operation.* Why the municipal water works should be entirely self-supporting; independent of all other functions of city government; and absolutely free from politics.

9. *Water Rates.* Give the public the detailed cost of producing and delivering water; and why the rates should be high enough to provide a fund for extensions and retirement of bonded indebtedness.

10. *Meters.* Why the all-metered system is the only just method for the sale of water. How it reduces waste, conserves supply, and thereby keeps down the water rates. That meters cannot over-register, but when damaged or worn out under-register. Why water used in city parks, street flushing, fire-fighting, should be paid for by the department using it, in order that the water department will be on a strictly business basis.

11. Urge the consumers to visit the reservoirs, filtration and chlorination works, and pumping plants. Show them that a few dollars in beautification is money well spent.

12. In other words, take the public into your confidence, and they will back you with all the money you need. This is very important when it is necessary to 'put over' a bond issue. A carefully planned campaign of publicity will ensure success.

So much for the education of the public. How can the water works superintendent get better educated so he can tell the public all the foregoing, and also make his water works the equal of, or better than, any other water works?

He must remember that 'big oaks from little acorns grow', and that water works practice of today and the resultant modern water works have grown from the small 'acorn' ideas of thousands of superintendents.

Modern improvements are the result of the interchange of these experiences and new ideas. This can be accomplished more quickly and better through the medium of technical periodicals than only by word of mouth, although affiliation with the American Water Works Association, and attendance at all the conventions and participation in the discussions, must not be neglected.

This is the 'when', 'how', and 'why' of the technical periodical. It is the medium at your command. Bear in mind that for every experience or new idea you pass on to the other fellow, you will get hundreds in return; or thousands if you all follow this method. Do not hesitate because you think you cannot write. Write it out in your own way, in pencil if a pen is not handy. Let the editor help you put it in shape.

Many times it is the short items that are the most valuable and interesting. Remember what may be regular routine or common practice for you, may be an innovation to someone else.

## A CORRECTION

*To the Editor:*

My attention has been called to an article in the November number (Vol. 21, No. 11) Proceedings, Journal of the American Water Works Association, page 1560, where at a session of the Superintendents' Round Table, I am reported as discussing the matter of "Hydrant Rentals."

This article places me in a very embarrassing position. The text of the discussion is entirely contrary to my convictions and ideas and conditions mentioned differ radically from any I have ever experienced.

I was present at this meeting for a short time and left after Mr. Brush had completed his discussion, page 1555. At no time during the convention did I take any part in the discussion of this subject.

I would ask that you take such action as may be necessary to have the record corrected.

Yours truly,

CHARLES R. BETTES.

# ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

**Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.**

**Rapid Winter Construction on a Hydro-Electric Plant.** Eng. News-Rec., 102: 311–3, February 21, 1929. Illustrated description of construction of Chippewa Falls hydro-electric plant and dam on Chippewa River in Wisconsin. Entire structure was housed in for winter work. Concrete was proportioned by water-cement ratio. Coarse aggregate was measured volumetrically and sand by inundation. Mixing period of 1 minute was employed throughout. Found that temperature of 68–76°F. in concrete discharged from mixer was sufficient to prevent freezing during transit to forms if mass was kept constantly in motion.—*R. E. Thompson.*

**Observation on Levee Plant, Methods, and Prices.** ARTHUR M. SHAW. Eng. News-Rec., 102: 296–9, February 21, 1929. Discussion of observations made on recent trip over Mississippi levees.—*R. E. Thompson.*

**Driving the Second Cascade Tunnel.** Eng. News-Rec., 102: 334–8, February 28, 1929. Detailed illustrated description and records of construction of new 7.8-mile Cascade tunnel of Great Northern Railroad through Cascade Range of Rocky Mountains.—*R. E. Thompson.*

**Reservoir Parapet Serves Useful Purpose and Adds Finish.** Eng. News-Rec., 102: 360, February 28, 1929. Reservoir of 25 million gallons capacity recently constructed in Tacoma, Washington, was formed partly by excavation, employing excavated material to build embankment, entire interior then being lined with concrete. A 3-foot coping around reservoir renders available storage up to elevation level with top of embankment. Coping also prevents waves from overlapping the fill, keeps dust and other wind-blown material out of reservoir and provides neat and finished appearance to structure as whole. A fence completely encloses reservoir.—*R. E. Thompson.*

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

**Handling Penstock Pipe on Buck's Creek Project.** DANIEL MCFARLAND. Eng. News-Rec., 102: 357, February 28, 1929. Brief illustrated description of placing of 9600 feet of pipe, 3 to 4½ feet in diameter, on two penstocks of Buck's Creek project of Feather River Power Co.—*R. E. Thompson.*

**City Liable on Faulty Water Supply Project.** Eng. News-Rec., 102: 388, March 7, 1929. Leaky condition of stave pipeline conveying water along mountainside to Ogden City, Utah, caused softening of soil and resulted in several landslides during heavy rains. Slides dammed stream in canyon below and resulting flood caused injury to adjoining property. Court held that the one maintaining such faulty flume was liable. City claimed that it was exempt from liability because it was engaging in governmental function. Court held that furnishing water to private citizens was the exercise of a proprietary function, not a governmental one, and in such undertaking city was liable. (EGELHOFF *vs.* Ogden City).—*R. E. Thompson.*

**Methods of Handling Quicksand in Sewer Construction.** A. P. LEARNED. Eng. News-Rec., 102: 392–3, March 7, 1929. Quicksand is not a material but rather a condition of a material. Any material of granular nature may become quicksand if there is upward movement of ground water through it of sufficient velocity to lift and carry the individual particles. There are a number of materials which when dry appear as shales or clays mixed with very fine sand and which in presence of water will often make bad form of quicksand. Clay or shale seems to act as lubricant for sand grains and they flow even more readily than similar small-grained sand which is clean and free from clay. Same materials when dry or confined usually make very substantial foundation. Methods of handling quicksand are described and appraised. Quicksand clauses in specifications are suggested, methods of payment being outlined and discussed.—*R. E. Thompson.*

**Spray Aërator for Filtered Water at Waterford, N. Y.** R. G. YAXLEY. Eng. New-Rec., 102: 498–9, 1929. Installation of a 1.5-m.g.d. spray-type aërator at Waterford, N. Y., has reduced tastes and odors in the filtered water and also reduced the amount $Na_2CO_3$ required to render the water non-corrosive. The supply is drawn from the Hudson River and is soft, highly-colored, and badly polluted with paper mill waste and sewage. The high dosage of alum required for coagulation together with 4–5 p.p.m. free $CO_2$ in the river water renders the water unsuitable for use without treatment to reduce its corrosiveness. The reduction in $CO_2$ effected by aëration is shown graphically, the percentage removal varying from 56 to 84, being lower with cold water. It is reported that the "soap hardness" of the water is reduced as the water passes through the aërator, the reduction being as high as 37 percent.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

**Charter Draft for Consolidated City of Pittsburgh.** Eng. News-Rec., 102: 496–8, March 28, 1929. Consolidated City of Pittsburgh "Composed of Allegheny County and the Cities, Boroughs, and Townships Thereof Under a Federal Plan" is provided for in bill introduced in Pennsylvania Legislature

March 11. Details of proposed plan given. If enacted, charter would be subject to referendum in June and become fully effective January 1, 1930. Except for public works and services county wide in scope or which might readily become so, including water supply, the 123 existing city, borough, and township areas and governments would be left undisturbed. County would remain as governmental unit, but for most part its public works and services would be transferred to consolidated City of Pittsburgh. Pittsburgh now has area of 49 square miles; Allegheny County, 725 square miles. Corresponding populations are about 675,000 and 1,315,000.—*R. E. Thompson.*

**This Material—Concrete.** NATHAN C. JOHNSON. **I. Difficulty of Standardization.** Eng. News-Rec., 102: 128–30, 1929. **II. Commercial Production of Concrete.** Ibid., 172–5. **III. Simplifying Quality Production.** Ibid., 263–8. **IV. Effecting Economies by Study of Cements.** Ibid., 314–8. A lengthy discussion of the factors affecting the quality and uniformity of concrete, the adequacy of present standards, and the reliability of specimen cylinder strength tests as an index of the quality of field concrete, together with suggestions for preparing more uniform concrete. The following outline specification is considered suitable: 1 part of cement, not over 2 parts of sand if the sand is coarse and less if the sand is fine, as much stone as the mix will carry, and only sufficient water to give a workable consistency without separation. A study of the properties of the "cement pulp" between the sand grains of concrete indicates economies and improvements which may be effected. This cement pulp absorbs water regardless of physical pores. Concrete exposed to water should therefore be protected irrespective of the quality of the product. Oil is ineffective for this purpose, as it will penetrate only the physical pores of the mass and not the pulp itself and the latter will continue to absorb water. Evaporation of the absorbed water brings to the surface dissolved salts and results in the efflorescences frequently observed on concrete. Set and hardened cement pulp will not bond with new cement mixtures except for a very limited time. If the surface of the aggregate of set concrete is washed free of cement pulp a reasonably effective bond may be expected. In the "mother liquor," a strongly alkaline solution which is formed as soon as cement and water are mixed the secondary products of the hydration of cement diffuse and spread. Much depends on the concentration of this mother liquor. If pure mother liquor is added to a normal cement-sand-stone mixture, the rate of hardening can be increased 300–400 percent. The alkaline mother liquor attacks the resins of wooden forms, causing warping and weakening. Application of an impermeable coating considerably increases the life of wooden forms.—*R. E. Thompson (Courtesy Chem. Abst.).*

**Study of Mixing Action in Large Concrete Mixers.** A. N. TALBOT. Univ. of Illinois. Eng. News-Rec., 102: 394–6, 1929. Data are given from an extensive report to the Koehring Co. of Milwaukee, for details of which the original must be consulted. Two forms of mixing action are necessary: (1) intermingling of the ingredients, and (2) rubbing or scrubbing action among the particles themselves. The slower speeds of rotation give a better mixing action; dry and medium mixes need a slower speed than do wet ones. A fine

sand mixture requires more vigorous action than one of coarse sand.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

**Rolled-Fill Earth Dam Constructed Without Shrinkage.** F. A. Lammiman. Eng. News-Rec., 102: 388, March, 7, 1929. Data given on rolled-earth dam built in 1926 on Philbrook Creek for Pacific Gas and Electric Co. Dam has crown of 12 feet, upstream slope of 1 on 2½ and downstream slope of 1 on 2. Length is 900 feet and height above stream bed 85 feet. Specifications called for selected material in core trench and upstream third of cross-section, and that fill be placed in 4-inch layers, each thoroughly tamped. Layers of moist clay and dry sand were placed alternately, tamping machine effecting mixing as well as compacting. Whole mass was brought to consistency very similar to that of waterbound macadam road with slight excess of clay filler. Completed fill totaled 142,000 cubic yards and borrowpits measured 169,000 cubic yards, showing shrinkage under tamping of about 16 percent. Reservoir was filled during winter of 1927, emptied during summer, and filled again in 1928. On May 23, 1928, actual settlement, as far as could be determined, was very close to zero. No seepage is apparent through fill, but about 0.8 second-foot passes under fill through foundation material.—*R. E. Thompson.*

**Motorizing the Hand Tool.** C. H. Vivian. Eng. News-Rec., 102: 528–31, April 4, 1929. Interesting data given on comparative costs of performing such operations as trenching, backfilling, joint calking, and cutting of cast iron pipe by hand and with power equipment.—*R. E. Thompson.*

**Weighted Gate Closes Opening in Multiple-Dome Dam.** Eng. News-Rec., 102: 386–7, March 7, 1929. Illustrated description of method of effecting closure of opening in one of domes of Coolidge multiple-dome dam through which stream flow passed during construction. Weighted timber gate was placed in front of opening, and watertight membrane and drains behind gate enabled concrete to be placed in the dry. By arrangement for finishing with grout under pressure, even cracks left by shrinkage of concrete plug were filled.—*R. E. Thompson.*

**The Chicago Sanitary District Situation.** Eng. News-Rec., 102: 396–7, March 7, 1929. Lack of funds, mismanagement, and recent Supreme Court decision necessitating large and immediate construction program for sewage treatment works have created serious situation in regard to Sanitary District of Chicago. Attempts to sell bond issue of $27,000,000 for construction program last fall failed because of legal proceedings brought by taxpayer, resulting in present financial crisis. District has applied to state legislature for authority to issue bonds without referendum. By Supreme Court decision, diversion of water from Lake Michigan will ultimately be prohibited except so far as water is required for navigation in Chicago River, amount of which is characterized as negligible. District therefore will have to provide treatment for entire sewage flow, or for estimated population of 3,710,000 in 1930, for considerable portion of which works of varying degrees of efficiency have been constructed or are under construction. Data given from lengthy and

scathing report of grand jury in which is shown gross mismanagement of affairs. Since report was made, number of employees has been reduced from 4780 to about 1200, and funds are insufficient to meet this payroll.—*R. E. Thompson.*

**Multiple-Tank Reservoirs at Cincinnati.** J. A. Hiller. Eng. News-Rec., 102: 414–7, March 14, 1929. Water supply of Cincinnati is drawn from Ohio River about 7½ miles above business center of city. From intake tower, a 7-foot tunnel leads to river pumping station where water rises in shaft serving suction headers of four 30-m.g.d. pumps which discharge through two 60-inch mains into 2 settling basins having combined capacity of 340 m.g. Latter also form reserve in case of interruption to supply. Water flows from basins by gravity through 100-m.g.d. purification plant (average daily consumption 50 m.g.) into 19-m.g. clear well. From latter water flows through 7-foot concrete-lined tunnel, 4½ miles long, in bedrock and at average depth of 150 feet below surface to main pumping station. Prominent feature of system is the use of groups of large steel standpipes enclosed with walls of architectural design in high level sections of city. Owing to diversified topography, the distribution system is divided into 3 districts, in each of which these tanks have been provided of capacity equal to at least 2 days average consumption of district. Illustrations are given of the various groups of tanks, and most recently built reservoir of this type, on Mount Airy, is described in some detail. Latter consists of 14 tanks, seven of 50 feet in diameter, two of 25 feet, and five of 22 feet, each being 70 feet in height. Combined capacity is 8.5 m.g. Exterior is faced with multi-colored brick laid in Flemish bond, annular space between shells and brick being filled with concrete. Interior is lined with 2-inch gunite to reduce maintenance.—*R. E. Thompson.*

**Pipe Braces Used to Hold Form Panels in Concrete Dam Construction.** Daniel McFarland. Eng. News-Rec., 102: 514, March 28, 1929. Brief illustrated description of successful method of holding concrete form panels in perfect alignment, developed by E. R. Stokes, which involves use of iron pipe braces wedged against panels from inside, replacing customary wooden braces. —*R. E. Thompson.*

**Facts Bearing on the Chicago Sanitary District Dilemma.** Eng. News-Rec., 102: 440–2, March 14, 1929. History of Sanitary District of Chicago is reviewed briefly and data given regarding the 6 sewage works already built and the one under construction, together with estimates of works yet to be provided. Considerable amount of information given was derived from 108-page descriptive pamphlet entitled "Engineering Works, Sanitary District of Chicago, August, 1928," issued by District.—*R. E. Thompson.*

**Recent Irrigation Developments in Mexico.** Vincent Saucedo. Eng. News-Rec., 102: 452–5, March 21, 1929. Population of Mexico averages 17 per square mile. Big factor in retardation of settlement of country has been scantiness and irregularity of rainfall. Small scale local storage schemes were undertaken in the past and during present decade the Water Board under the

Department of Agriculture divided country into number of natural watersheds to attain unity of purpose. In 1926 a National Irrigation Commission was created. Tabulation is given of principal systems in construction or under consideration, with their main features, and Nueva España system is described in some detail. Latter consists of 1,136,000-acre-foot reservoir covering about 50,000 acres in valley of Salado River. Main dam is of earth and gravel, 3484 feet long, with maximum height of 105 feet. Width of base at deepest point is about 414 feet. One end abuts against hill and other is joined to concrete overflow extension. Dike is more than 6 miles long and reaches height of 32 feet. Final cost is estimated at $12,000,000 (Mexican currency). —*R. E. Thompson.*

**Behavior of Rivers in Alluvial Plains.** Roy N. Towl. Eng. News-Rec., 102: 433–5, March 14, 1929. Discussion of advantage of straight river courses in comparison to crooked ones, with particular reference to Mississippi River. Observations on various rivers show that shortening and straightening is continually taking place.—*R. E. Thompson.*

**Field-Welded Pipe Hung on Canyon Walls Carries Water Supply.** C. J. Ullrich. Eng. News-Rec., 102: 465–7, March 21, 1929. Illustrated description of construction of 6½-mile, 10-inch pipe line recently installed to carry water from Cluff Spring to Cedar City, Utah, a town of 4,000 population. Spring issues from side of cliff in Coal Creek Canyon at elevation of 600 feet above canyon floor and flow varies from 1 to 10 second-feet. Pipe line is 12-gage, butt-welded, ingot iron, open end flow line, total fall being 1234 feet and maximum hydraulic gradient pressure 110 pounds per square inch. Route skirting hillside was chosen, topography of ground transversed being rough and irregular. Line crosses numerous small gulleys and goes over steep ridges and around sheer rock cliffs. Almost every one of 1430 field joints had to be cut at an angle and in addition 237 lengths of pipe were cut and rewelded at angle to conform to contour of ground. These angles were all cut and welded in field with acetylene. At one point where line passes around rock cliff for distance of 800 feet, eyebar rods were drilled into rock every 10 feet, projecting 3 feet from face of cliff, wire cables being passed through eyes and fastened to similar rods drilled into cliff 6 feet above and projecting 6 inches. Entire pipeline, except where passing around cliffs and over washes is buried in trench 18-inches deep. On steep hillsides pipe was anchored to masonry anchor blocks every 150 feet. Pipe was fabricated in 24-foot lengths at contractor's plant, each length consisting of four 6-foot sections in which longitudinal joints were made with automatic arc-welding machine and circumferential joints with acetylene welding torches. Each 24-foot length was tested for leakage under hydrostatic pressure of 300 pounds per square inch and coated inside and out by dipping in asphalt base compound. Air-release valves and air and vacuum valves were placed on all major high points and blowoff valves at all major low points, pet-cock type air valves and drain valves being installed at secondary high and low points respectively. Expansion joints were placed in line every 1000 feet where buried and every 500 feet where exposed. Laying of line was commenced in December, 1927, and completed in April, 1928. Com-

plete inspection after turning on water failed to disclose single leak. Remarkable results attributed to fact that ingot iron melts and flows uniformly under heat of acetylene torches without developing gas pockets.—*R. E. Thompson.*

**Some Observations on the Water of the Red Hills Lake at Madras (1925-8).** T. N. S. Raghavachari and S. V. Ganapati. Indian J. Med. Res., April, 1929. Advance proof. Water supply of Madras is derived from Red Hills Lake, being conveyed a distance of 7 miles to city through closed masonry conduit. Slow sand filters installed in 1914 have not been successful owing to their inability to produce a uniformly good effluent and to the production of hydrogen sulfide in the sand beds during summer months. Results are presented of detailed study of supply commenced in 1925 to throw light on this problem. In December and January, when lake is full due to heavy rains, depth varies from 4 to 25 feet and during summer season, from few inches to 8–9 feet. Temperature varies between 24 and 31°C., depending on season, and during summer, when there is no influx of fresh water, pronounced stratification occurs. In bottom layers, accumulations of organic matter are present at all times, being particularly excessive in summer when they are of nature of a black ooze which liberates hydrogen sulfide on acidification. The water is drawn for supply from depth of 3–5 feet below surface and is always deficient in dissolved oxygen, varying from 1.2 percent less than saturation in December to as much as 24 percent in August. At lower depths greater deficiency exists. During passage of water through conduit a further depletion of oxygen occurs, due probably to excessive growths on walls. Slow sand filtration further markedly reduces oxygen concentration, even on first day that filter is in service. There is a consistent and progressive reduction in oxygen content of filtrate from day to day and when hydrogen sulfide appears in effluent there is further progressive reduction, complete absence of oxygen occurring finally as the hydrogen sulfide increases considerably. During period of heavy rains, December to March, when water is practically saturated with oxygen, the hydrogen sulfide content of effluent is very low. This indicates that production of hydrogen sulfide is due to anaërobic putrefactive processes in filter resulting from oxygen deficiency, similar to those which occur in bottom of lake. Experiments of Government Committee on Water Supply and Purification have shown that aëration of Red Hills Lake water by passage through percolating filter eliminates production of hydrogen sulfide when water is applied to a sand filter even during hottest season of year. Data are also included on algae and higher plants present in the water, and seasonal variations of temperature, dissolved oxygen, oxygen consumed and pH are shown graphically. Among higher plants, *Chara* were found to predominate. According to Whipple, species of this plant produce hydrogen sulfide in abundance on death and decay. The oxygen consumed value of the lake water varies from about 1.2 p.p.m. in January to in excess of 2 p.p.m. in August, and pH value from 8 to 9.5 respectively.—*R. E. Thompson.*

**Water District to Direct Colorado River Aqueduct Project.** Eng. News-Rec., 102: 512, March 28, 1929. Permanent organization of Metropolitan

Water District of Southern California, formed to design and direct construction of water supply aqueduct (300 miles long) from Colorado River, has been effected to include nucleus of 11 cities. Passage of Boulder Dam bill stimulated activity in this connection. District is authorized to levy tax not to exceed 5 cents per \$100 assessed valuation for preliminary expenditures. Bonds for construction purposes may be issued at not less than par value following approval by majority of electors of district. Tabulation given of cities comprising district, together with assessed valuation, etc. Although Los Angeles comprises 82 percent of assessed valuation, provision is made that no city is entitled to more than 50 percent of total votes of district. Each city is entitled to one vote for each \$10,000,000 of assessed valuation or major portion thereof, with above exception. Representation on board of directors is proportioned at minimum of 1 representative to each city, with additional representative for each \$200,000,000 of assessed valuation.—*R. E. Thompson.*

**New Suggestions for Utilizing Pulp Waste-Liquors.** A. Schrohe. Papier-Fabr., **26**: 241–8, 1928. From Chem. Abst., **22**: 3295, September 10, 1928. Review of patents issued during 1925–6–7. Cf. C.A., **19**: 2564; 20, 988.—*R. E. Thompson.*

**Determination of Phenols in Waste Waters.** M. Horn. Kl. Mitt. f. d. Mitglied. f. Wasser-, Boden-, u. Lufthygiene, **5**: 52. 1929. The author describes the most commonly used tests for phenol, without offering an opinion as to which is the most suitable. Phenols are divided into two classes, those volatile and those non-volatile in steam. River water needs to be examined for volatile phenols only, but effluents should be examined for both types. Phenol, cresol, thymol, pyrocatechol, and a little of the naphthol are volatile in steam on distillation from an acid solution; most of the naphthol, some pyrocatechols, hydroquinone, resorcin, pryogallol, and phloroglucinol are not volatile. *Determination of non-volatile phenols.* The diluted residue in the still is made alkaline with soda, and ether added to remove any fatty matter. Aqueous layer is acidified and phenols extracted with ether. This ether layer is dried with sodium sulphate, freed from ether, and phenol residue weighed. *Determination of volatile phenols.* Some effluents contain volatile compounds such as hydrogen sulphide, other sulphides, benzine, thiosulphate, thiocyanate, and cyanides, which must be removed before determining the volatile phenols. There are two usual methods. In the method after O. Korn, 5 cc. of a concentrated solution of lead acetate is added to 100 to 500 cc. of the effluent, and the mixture left for 24 hours. The filtrate, diluted to 100 cc., is acidified with 10 cc. of dilute sulphuric acid (1:3) and distilled until the vapor passing over no longer gives a reaction for phenol. After addition of calcium carbonate, this distillate is redistilled, and the final distillate used for phenol determination. In the second method, after Bach and Uthe, 5 cc. of sulphuric acid (1:3) is added to 100 cc. of the effluent and the solution evaporated. The residue is dissolved in 100 cc. of water and distilled. The distillate containing the phenols is filtered and heated gently until all hydrogen sulphide has been driven off. About 1 cc. of barium chloride solution and 2 drops of phenolphthalein are added and then dilute soda until solution is

weakly alkaline. Boiling is continued until crystals of barium sulphate and carbonate develop. Solution is filtered hot and resulting filtrate used for the determination of phenols. Effluents which do not contain volatile compounds are acidified and distilled, and the distillate used for phenol determination. *Qualitative Detection of Phenol.* (1) Excess bromine water gives a yellow precipitate with phenols. (2) BAEYER-MELZER reaction. One cc. of distillate, 2 cc. of concentrated HCl, and a drop of benzaldehyde. In presence of phenol a red, resinous precipitate forms, which turns a blue-violet with alkalies (*p*-cresol gives a dark brown floc). With concentrated $H_2SO_4$, and a drop of formaldehyde, phenol forms a red-violet ring, and *p*-cresol a brown ring. (3) FRIEBER reaction. One cc. of 10 percent soda solution and 0.5 cc. of fresh 0.1 percent solution of *p*-amidophenol hydrochloride are added to 10 cc. of the distillate, and 2 to 3 drops of sodium hypochlorite solution are added below this mixture. If phenol is present, a clear to deep blue color forms at the junction of the two layers and gradually diffuses through the liquid and turns brown. (4) MILLON's reagent is a solution of 1 part mercury, 1 part concentrated nitric acid, and 2 parts water. On heating, this gives a rose-red color with phenol and a brown-red with cresol. (5) F. HINDEN uses a diazo reagent which gives a brown red color with phenols. It is prepared by dissolving a small quantity of *p*-nitraniline in 20 cc. of distilled water and adding 5 cc. of dilute sulphuric acid and a crystal of sodium nitrite. First three drops of the diazo solution and then 5 drops of concentrated soda are added to 20 cc. of the distillate. The reagents must be added in the correct order and a control test is advisable. (6) FOLIN and DENIS prepare a reagent by dissolving 100 gm. sodium tungstate in 750 cc. water and adding 18 gm. molybdenum trioxide and 50 cc. 85 percent phosphoric acid. After heating for two hours, solution is made up to 1 litre: 1 cc. of the reagent is added to 10 cc. of the distillate and also 2 cc. of a saturated sodium carbonate solution. Phenol, even if only present in very small quantities, gives a blue color, and cresol a greenish blue color. *Quantitative Determination of Phenols.* (1) FOLIN and DENIS. One cc. of the reagent for every mg. per litre of phenol is added to 50 cc. of the distillate with 5 cc. of saturated sodium carbonate solution. The color is compared with that of similarly treated standardized phenol solutions. (2) MESSINGER and VORTMANN. The phenol in the warm distillate, made alkaline with 15 cc. N/10 NaOH, is converted into tri-iodo phenol by adding 30 cc. of N/10 iodine solution. This mixture is acidified with 10 cc. sulphuric acid (1:3) and the excess iodine titrated with N/10 thiosulphate. One cc. of iodine slolution corresponds to 1.5675 mg. of phenols. This titration method should not be used for very small quantities of phenol. (3) KOPPESCHAAR. Fifty centimeters of N/100 bromine solution, or 20–50 cc. N/10 solution if the phenol content of the distillate is high, is shaken with the slightly alkaline distillate in a 250 cc. flask; 5 cc. of concentrated HCl are added, and after shakin gagain, mixture is left for about an hour. Two grams potassium iodide are added, mixture shaken, left for 10 minutes, and the free iodine, which is equivalent to the residual bromine, titrated with N/100 or N/10 thiosulphate solution. The phenol is calculated as in (2) from the difference. A stable N/10 bromine solution is prepared with 2.7837 gm. of pure dry potassium bromate and about 10 gm. of potassium bromide in 1 litre of water. In titrations of mixtures of

phenol and cresol, the cresol content is always lower than the theoretical value.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**A Rapid Conductivity Titration Method for the Determination of Sulphate in Public Water Supplies.** H. FERN, G. JANDER and O. PFUNDT. Z. angew. Chem., 42: 158, 1929. Rapid electrical methods for determining sulphate in water are taking the place of the slower gravimetric method. The electrometric methods usually involve the use of a telephone, which necessitates many readings. The telephone may be replaced by a small transformer, with a thermo-couple placed on the secondary connected to a galvanometer. The galvanometer deflections, as definite quantities of precipitant are added, are plotted graphically. During these measurements the resistances, other than that of the solution in the bridge, are kept constant. At the end-point the direction of the curve of the galvanometer deflections changes sharply. Barium acetate is preferable to the chloride as precipitant since its conductivity is lower, and addition of alcohol is also an advantage, for same reason. Any bicarbonate present in the water should be removed by boiling and filtration, as its presence results in curves without sharp change in direction. Titrations should be made immediately after adding the alcohol, because calcium sulphate is precipitated if the mixture is left to stand.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**A Convenient Apparatus for the Measurement of Hydrogen Ion Concentration by an Electrical Method.** JAN SMIT. Von Wasser; Ver. deutscher Chemiker, Berlin, 2: 173, 1928. In spite of the great advance in apparatus for pH estimation, the hydrogen electrode still causes difficulty by requiring re-platinising at short intervals and treatment with pure hydrogen before every estimation. This is specially inconvenient when the apparatus is not in continuous use. The author gives a description of the apparatus constructed by him according to the models of BARENDRECHT. This has the advantage that the hydrogen electrode remains constantly in a continuously renewed atmosphere of hydrogen saturated with water vapour. The electrode remains usable for months whether in constant use or not. The apparatus and the method for use with different solutions are fully described as is also the simplified method used for re-platinising the electrode when necessary. The apparatus has been in constant use in the Laboratorium voor de Gezondheitsleer at Amsterdam for about four years. It can be recommended to those who wish to estimate pH value in 30–60 minutes without the use of several litres of hydrogen and a fragile and expensive apparatus.—*H. M. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**The Fauna and Ecology of the Kara Sea.** I. D. STRELNIKOV. Comptes Rendus. Acad. des. Sci., 188: 931 and 1008, 1929. The most important species found in the different zones are enumerated. The plankton is poor in species

owing to the low salt content of the water; littoral and sub-littoral fauna are absent, except in a few places, because of the frozen water near the shore and floating ice, but the benthotic flora is very rich owing to the quantities of ooze deposited by the rivers flowing into the Kara sea.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

**The Chlorine Absorption Capacity of Water.** BESEMANN. Vom. Wasser, Ver. deutscher Chemiker, Berlin, 2: 64, 1928. Experiments were undertaken to determine whether the chlorine absorption capacity of water was caused by organic or by inorganic matter and on what outside influences it depended. Estimations according both to BRUNS and to OLSZEWSKI were made with distilled water, alone and with added urea, dextrose, calcium carbonate, beef juice, plant juice, lignite, humic acid, and phenol, and also with natural water. The following conclusions were reached: (1) that the chlorine absorption capacity was affected both by organic and inorganic matter; (2) that it did not depend on pH value; (3) that experiments upon the action of chlorine should take place in the dark; (4) that either a solution of chlorine in water or a hypochlorite may be used indifferently; (5) that the capacity is affected by temperature; (6) that the time of action should normally be 5 minutes; (7) that OLSZEWSKI's method, requiring no excess of Cl, is specially suitable for practical application; (8) that BRUNS' method should be used to determine the effect of an excess of Cl. The conclusions of WETTE, based upon experiment with chemically pure urea, dextrose, and olive oil, that organic matter does not influence the chlorine absorption capacity, are thus contrary to experience.—*H. M. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

**Permanganate consumption, Chlorine-number and Chloramine-number in water and effluent analysis.** F. EGGER. Vom Wasser, Ver. deutscher Chemiker, Berlin, 2: 56, 1928. FROBOESE introduced a method of ascertaining organic impurities in water by boiling with sodium hypochlorite solution and expressed the degree of impurity by the chlorine consumption, calling this the chlorine number. BACH and GLASER proposed to use an alkaline chloramine solution instead of the hypochlorite. The writer describes a comparison of the permanganate consumption value, the chlorine number, and the chloramine number. The chlorine-number and the chloramine number gave entirely different results. The chloramine number was lower than either the chlorine number or the permanganate consumption, for chloramine has less action on the decomposition products of albumen and urea. The chlorine number varies with the strength of the diluted effluent and the concentration of the oxidizing agent. Therefore it can only be applied when the conditions of experiment are completely fixed. On the other hand the permanganate consumption can be usefully estimated with different concentrations of permanganate and of effluent, for the value does not vary much with amount of permanganate added. In the case of slightly polluted water or normal ground and surface water, a simultaneous estimation of chlorine number and permanganate consumption gives valuable information as to the condition of the

water.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**A Contribution to Knowledge of the Chlorination of Effluents.** E. MERKEL. Vom Wasser, Ver. deutscher Chemiker, Berlin, 2: 52, 1928. The chlorination of effluents has proved valuable in all cases except in a few biological purification plants. The addition of chlorine treatment to the purification of effluents from a residential district at Nürnberg was successful in getting rid of smell 'round the plant, hindering the blocking of the sprinkling filter, and decreasing the biochemical oxygen demand. This decrease had, however, little effect on the biological purification effected by the sprinkling filter.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**Recent Experience in the Disinfection of Swimming Bath Water.** W. OLSZEWSKI. Vom Wasser, Ver. deutscher. Chemiker, Berlin, 2: 33, 1928. Sodium hypochlorite was tried in solution without ammonia. Less excess of chlorine was needed, but the water had smell and taste of hypochlorous acid. Tests were made with sodium hypochlorite and ammonia. Smell and taste were no longer noticeable and *B. coli* count was satisfactory, though agar germ count was higher than with chlorine gas. This was not the case in laboratory tests. For large baths the most convenient method is addition of chlorine and ammonia in dilute solution to the water. For small baths sodium hypchlorite and ammonia in solution give good results. Experiments have also been made with nitrogen trichloride and with ammonium chloride. Where space was available, the addition of aluminum sulphate before filtration gave good results. During discussion the objection that chlorination caused asthma was answered by ORNSTEIN, who said that complaints of the evil effects of the use of chlorine were generally imaginary.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**Treatment of Water and Effluents with Chlorine in America.** G. ORNSTEIN. Vom Wasser, Ver. deutscher Chemiker, Berlin, 2: 41, 1928. For the great water supplies both of New York and Chicago only chlorination is used. Double chlorination has been found very successful even in very polluted waters. Treatment with ultra-violet rays has been tried for swimming baths but has not proved satisfactory. For effluents America has adopted chlorination very largely. The method used is to chlorinate before clarification with, if necessary, a further chlorination afterwards. The previous chlorination has no detrimental effects on the sludge which, after treatment with iron sulphate solution, can be drained, dried, and used as manure. In **Disscussion,** BRUNS emphasized danger of typhoid epidemics arising from defects in, or negligence in use of chlorinating plants. Chlorination for drinking water should preferably not be constant, but applied when examination showed it to be necessary. He also stated that disinfection of tannery effluents from anthrax germs was only in experimental stage. ORNSTEIN stated that if a very slight excess of Cl remained in the water, there was no aftergrowth of

germs.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**De-aëration of Feed Water for Boilers.** G. and J. Weir, Ltd. and J. Sim. B.P. 306, 257. J. Soc. Chem. Indust. Abstracts **48**: 342, 1929. The feed water, after pre-heating in the condenser of a steam-jet injector, is sprayed into a de-aërating chamber maintained under reduced pressure. It passes out of the chamber through two annular wells, in the second of which it is boiled vigorously by a direct-contact steam heater. The steam passes into a main chamber and is condensed by a water spray. The water level is regulated by means of a float-operated valve.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**The Application of Colloids to Boiler Scale Prevention.** E. Sauer. Vom Wasser, Ver. deutscher Chemiker, Berlin, **2**: 139, 1928. Experiments were undertaken to investigate action of colloids on bicarbonates and sulphates to determine whether addition of colloidal matter to boiler feed water prevents separation of hard crystalline matter or sludge. Addition of colloids to water containing bicarbonates had strong influence on course of thermal softening. Colloids hinder formation and increase of nuclei of crystallisation and prevent precipitation. Dextrine, gelatine, and agar showed more effect than gum arabic. Increased pressure lowered the effect. On addition of colloids to water containing calcium sulphate under pressure and at different temperatures, a quantity of calcium sulphate, corresponding to the decrease in solubility under increased temperature, separated. Calcium sulphate, in presence of colloid, was found in 3, and sometimes 4, degrees of dispersion, namely, (1) in solution as ions, (2) in colloidal solution, (3) as a fine-grained deposit containing some organic colloids, and sometimes (4) as a hard stony deposit.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**Collection of References to Colloid Technology. 9. Water and Sewage.** F. Sierp. Kolloid Z, **47**: 372, 1929. The author summarises the progress made, since the publication of R. E. Liesegang's "Kolloidchemische Technologie," in the technology of water supply and removal of sewage, made possible by the extensive research carried out in colloidal chemistry. The methods for purification of surface waters for drinking purposes and the preparation of waters for use in certain industries, are much improved. Colloids play an important part in water softening, especially in the prevention of boiler scale formation. The latest discoveries in de-acidification, removal of iron, manganese, suspended and colloidal matter, and oil and fats from raw waters are briefly described. The most recent improvements in the methods for sewage and effluent purification, both by submerged contact aërators and by activated sludge are summarized. Reference is made to fifty articles by German, American, and English authors in recently published journals.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

**How a Small Village Improved Its Water Supply.** FRANK C. ROE. Municipal News and Water Works, 76: 107–8, 1929. Niagra, Wisconsin, a village having a population of 1943, finding its water supply lacking in quantity and quality sought to remedy the condition. Of all avilable sources, the cheapest supply whose quality was also best was found to be from natural springs having a flow varying from 60,000 to 130,000 gallons per day. The construction necessary included an infiltration gallery, consisting of a main 572 feet in length, a reservoir 34 feet wide, 56 feet long, and 14 feet deep, and a pump house.—*C. C. Ruchhoft.*

**Regulations Governing Missouri Public Water Supplies. Revised.** ANON. Municipal News and Water Works, 76: 186, 1929. In revising the regulations governing water supplies, the State Board of Health of Missouri has included the following regulations: Samples of water from public supplies must be collected as authorized by the State Board of Health and examined bacteriologically and chemically in their laboratories: requirements are given for the number of samples to be taken periodically, the method of collection, charges for transportation, and fees for analysis.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

**Recording Operating Data on Filtration.** WELLINGTON DONALDSON. Municipal News and Water Works, 76: 235–6, 1929. One of the most important parts of plant operation is maintaining plant records so that comparisons can be made from time to time with the runs in the plant and with other plants. Records should consist of (1) primary reports on quantities, water quality, and general plant operation, (2) summaries of primary records, and (3) reports to department heads or supervisors.—*C. C. Ruchhoft.*

**Remedying Troublesome Conditions in Filter.** R. W. FITZGERALD. Municipal News and Water Works, 76: 238, 1929. The causes of hard spots, cracks, and mud balls in filters are improper coagulation, insufficient sedimentation, bacterial and algae growths, and washes at low velocities for short periods of time. These objectionable conditions lower the quality of the effluents, decrease length of filter runs, and increase the number of washes. Preventative treatments are thorough coagulation and sedimentation, prechlorination, and high velocity washes. Curative treatments are scraping, skimming, or removing and washing the sand.—*C. C. Ruchhoft.*

**Natural Basins Flooded to Increase Flow of Supply Wells.** Anon. Municipal News and Water Works, 76: 221, 1929. The utilization of natural bowls for storing water and supplementing the supply from wells was used as a means of increasing the water supply of Newton, Mass. Water from the Charles River was pumped to one bowl 1200 feet away. The water filters through an underlying stratum of gravel and sand and reaches the level of the wells. After 10 days of pumping water into the bowl, an increase of 230,000 gallons per day was found in one of the wells and 550,000 gallons in another; an increase of 40 percent being furnished by both. Two bowls thus prepared have a com-

bined capacity of 6,500,000 gallons. Experimental results show a recovery by the wells of about 56 percent of the water pumped to the bowls.—*C. C. Ruchhoft.*

**Chlorinated Copperas and Ferric Chloride as Coagulants.** L. H. ENSLOW. Municipal News and Water Works, **76**: 227–29, 1929. Chlorinated copperas as a coagulant is proving to be more effective and cheaper than the older coagulants, alum and copperas with lime. The theory is that the copperas ($FesO_47H_2O$) alone has no coagulating effect, but that oxidation by chlorination to the ferric state produces rapid coagulation. Ferric iron produced from the cheapest iron salt, copperas, and the cheapest oxidizing agent, chlorine, makes this process desirable. The copperas is dissolved in a vat which leads to the raw water through a corrosion-resistant pipe line. Beyond the vat chlorine water is introduced into the pipe line through a rubber hose. One part of chlorine to 8 parts of copperas is used. Waters having wide ranges of pH values are efficiently treated with ferric salts. Cost data are given.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

**Size and Behavior of Sand in Rapid Sand Filter Plants.** PAUL HANSEN. Municipal News and Water Works, **76**: 107–8, 1929. A presentation of phases and experimental work done in filter bed construction is given. The FULLER experiments in 1897 showed that a 30-inch bed is most effective and that sand, instead of crushed quartz, could be used. The Ohio State Department of Health in 1908 showed that sand grains having an effective size of more than 0.35 mm. is not satisfactory; but now, with the use of bleach and chlorine, a larger grain, up to 0.50 mm., can be used. Methods widely used in specifying size of sand were devised by HAZEN, and the terms "effective size" and "uniformity coefficient" introduced by him still prevail. The Bureau of Standards has developed standard sieves used in specifying sizes of sand grains. Experiments to determine the optimum size of sand grains and the best depth and grading of sand beds to meet the requirements of waters of different types are being carried out by a committee of the American Society of Civil Engineers.—*C. C. Ruchhoft.*

**Water Supply Cost.** Anon. Municipal News and Water Works, **76**: 198, 1929. In a report, "Physical Conditions and Public Service" of the Metropolitan N. Y. Region, expenditures required for supplying water to large population centers are given. The total cost of the Catskill System of N. Y., constructed between 1907 and 1926, was $188,000,000; thus providing 600 million gallons daily with a unit cost of $313,000 per million gallons daily. The cost of the Ridgewood System of Long Island from 1850 to 1906 was $16,900,000; furnishing 127 million gallons per day with unit cost of $133,000. The new system of the Boston Metropolitan District to supply 202 million gallons daily would cost about sixty million dollars, or $300,000 per million gallons daily. Costs are also given for the North Jersey district and districts about New York. The average per capita cost of developing water supply is about $60. The average consumption per capita in New York City in 1925 was about 140 gallons per day. The distributing system of Ridgewood up to 1906 cost about

$13,000,000 and New York was spending about eight millions per year on its distribution system. The per capita cost for extension and improvements has increased from five cents in 1919 to ninety-one cents in 1924 and decreased to eighty-five cents in 1925. The per capita expenditure on the basis of increased population was about $53 in 1925.—*C. C. Ruchhoft.*

**Improving the Operation of Water Treatment Plants in Maryland.** Anon. Municipal News and Water Works, **76**: 183–184, 1929. The coöperation of the Maryland State Department of Health with the water supply treatment plants throughout the state has resulted in improvements of plants and a reduction of diseases traceable to inadequate sanitary methods and facilities. Inspection by engineers of public water supplies is made periodically; also analyses. Recommendations are made as to chlorination, control methods, and apparatus. Weekly reports are made by plant operators to the health department. The effect of the work by the department has shown encouraging results as measured by the typhoid rate which in 1928 was the lowest it has ever been.—*C. C. Ruchhoft.*

**Materials of Construction.** Chem. & Met. Eng., **36**: 9, 521–76, September, 1929. September issue devoted to articles on materials of construction, largely relating to the chemical industry. **What the Chemical Engineer Demands of Construction Materials.** W. R. Huey. There are only 4 materials being used in the chemical industry today that have a very extensive application. They are high-silicon iron, fused silica, glass and stoneware. All others have only limited applications. These four materials are brittle and there is much breakage, caused by temperature changes. The list of corrosion-resistant alloys is increasing rapidly. The high-chromium stainless alloys of iron offer some encouragement that the ideal alloy will yet replace some of the old reliables. **Selecting Metals for High-Temperature-Pressure Requirements.** S. D. Kirkpatrick. Ten years ago pressures seldom exceeded 100 pounds per square inch. Today it is not uncommon to operate at 750 pounds, or higher, with temperatures approximately 1,000°F. Tubes in oil cracking stills may gradually give way by the walls becoming progressively thinner caused by creep. A method for testing the creep of metals in the Creep Point Laboratory of the Standard Oil Development Co. is described. **What Chrome-Nickel Steels Offer to Chemical Engineers.** J. A. Mathews. **How Chrome Steels Serve the Nitrocellulose Manufacturer.** T. McKnight. **Chromium Iron and Steels Exhibit Widely Varying Properties.** W. M. Mitchell. The author describes the various chromium irons and their uses. **High-Chromium Cast Steel Flue Becomes Severely Brittle.** J. D. Davis. Cast high-chromium steel is not an ideal material when the service requirements involve alternate heating and cooling in contact with flue gases. It becomes very brittle and may develop cracks. **Cheaper Low Alloy Steel for Numerous Applications.** J. Strauss. Where corrosion conditions are not severe, low alloy steels may be satisfactory. Steel containing 1 percent copper is finding much use as oil lines and other piping in moist soil and under water. Various alloy steels showing considerable corrosion resistance are those containing 0.5 to 1 percent copper and 1 to 4 percent chromium; nickel

steels containing 2 to 5 percent nickel; chrome-nickel steels containing approximately 4 percent nickel and 1 percent chromium; chrome-vanadium steels containing 1 to 1.5 percent chromium and 0.2 percent vanadium; and a few others. **Weak Sulphuric Acid Yields to Nickel-Silicon Steels.** W. B. Earnshaw. Rolled grades show ultimate tensile strength of from 90,000 to 110,000 pounds and castings, of approximately 75,000 pounds. These steels are highly resistant to weak hot sulphuric acid, aluminum sulfate, and calcium hypochlorite. **Low-Cost Corrosion Resistance with Alloyed Cast Iron.** J. S. Vanick. Alloyed cast iron offers some degree of relief from losses by corrosion at a low cost. Silicon in quantities in excess of the usual amount may be expected to decrease corrosion in tap water and sea water, and to increase corrosion in soil, and in acid or alkaline solutions. Nickel reduces corrosion in tap water, soil, sea water, and in acid or alkaline solutions. Copper seems to be effective against acid solutions, sea water, and atmospheric attack; but it is dormant, or actually detrimental, in tap water, distilled water, and alkalies: the limited solubility of copper in cast iron prevents its application in appreciable quantities. Chromium, in small additions, is effective against tap water, sea water, and weak acids. Combination of nickel and chromium presents prospects of improved corrosion resistance for many applications. These metals also improve resistance to wear. Nickel and its accessories, silicon and manganese, are the principal alloying elements used in the production of high-strength cast iron. **Inhibitors as a Means of Reducing Corrosion.** E. L. Chappell. Inhibitors are chemicals which, when added to an acid solution, prevent or diminish acid attack upon metals. The original and principal use is in pickling tanks where scale is removed from metal products. Recently it has been found practical to remove rust accumulations from clogged water lines by rust solvent consisting of commercial muriatic acid plus an inhibitor. **Early Obsolescence May Dictate Iron and Steel.** E. L. Chappell. The most common form of corrosion, ordinary rusting, is water-and-oxygen corrosion. When the natural corrosion does not cause failure before the end of the useful life it should be allowed to proceed. **Where High-Silicon Irons Serve Chemical Industry.** Anon. **New Alloys Withstand Hydrochloric Acid.** B. E. Field. "Hastelloy" is a nickel-molybdenum-iron alloy of high strength and good ductility. It is resistant to hydrochloric and nitric acids, wet chlorine, acid solutions of ferric salts, and cupric salts. **Varied Application Characterizes Aluminum in Industry.** P. V. Faragher. Aluminum is unaffected by contact with pure water; however, some natural waters contain sufficient concentrations of salts to cause serious corrosion. The action of various chemicals on aluminum equipment is given. **Nickel and Nickel Alloys Offer Diverse Corrosion Resistance.** R. S. McKay. The use of nickel in alloys as a constituent for increasing corrosion resistance is wide and varied. Pure nickel is fairly resistant to acids, alkalies, and salts. High nickel-chromium alloys, and nickel-chromium-iron alloys are resistant to oxidation up to high temperatures and are passive to corrosive attack in the presence of oxidizing agents and some acids. The best known high-nickel copper alloy is Monel metal. This alloy is more resistant to acids and alkalies than pure nickel and has higher mechanical properties. An alloy of nickel with chromium and copper is well fitted for service in valves handling high-pressure steam. **How Chemical**

**Industry Applies Copper and Copper Alloys.** W. H. BASSETT. Among the copper materials which are being used extensively in the chemical industry are deoxidized copper, red brass, aluminum bronze, Tempaloy, Ambrac, and Everdur. Red brass is a corrosion-resistant material composed of 85 percent copper and 15 percent zinc. Red brass pipe is used for unusually severe water conditions where material better than ordinary brass is required. **Tantalum: a Metal for Difficult Corrosion Problems.** C. H. JONES. The cost of tantalum is about one-fourth that of gold. It has excellent corrosion resistance to most acids and is inert toward aqua regia and wet or dry chlorine. **Unfamiliar Uses Increase Tin Applications.** C. L. MANTELL. Tin is widely used in alloys. There is no oxidation of the metal at ordinary temperatures. **Precious Metals for Ultimate Corrosion Resistance.** F. E. CARTER. The precious metals show great powers of withstanding chemical reagents. The advantages of these metals for certain uses are given. **Chamber Acid Depends Upon Lead.** G. O. HIERS. **Zinc and Its Alloys Resist Atmospheric Corrosion.** W. H. FINKELDEY. Bright zinc rapidly tarnishes and forms a surface film that is not readily soluble in ordinary atmospheric waters. **Electro-Deposited Films for Resistant Surfaces.** C. G. FINK. Ordinary steel and yellow brass covered with a corrosion- and wear-resistant metal are products costing but fractionally as much as the best corrosion-resistant alloys. One of the most widely used corrosion-protective metals is chromium. **Stellite for Resistance to Erosion and Abrasion.** W. A. WISSLER. This is a cobalt-chromium-tungsten alloy having a high resistance to wear and abrasion. **Where Chemical Engineers Use Hard Rubber in the Plant.** D. E. JONES. Hard rubber is highly resistant to a large number of chemicals. It is being used for pipes and fittings, and for the lining of steel tanks. **Soft Rubber: a Versatile Lining for Process and Storage Equipment.** N. G. MADGE. Soft rubber is being used for lining tank cars, tanks, piping, etc. **New Importance Attaches to Glassware as Construction Material.** E. A. MARSHALL. **Wide Variety of Ceramic Materials Find Industrial Application.** G. H. BROWN. Chemical stoneware is used very extensively for handling corrosive liquids. **Special Treatments Increase Resistance of Portland Cement Concrete.** S. R. MITCHELL. Most of the severe corrosion of mortars, stucco, and concrete work may be attributed to improper materials and workmanship. Extreme density is now being obtained in the manufacture of concrete pipe. Treatment of the surface helps to improve corrosion resistance of concrete. **Chemical Brick and Cement Afford Long-Time Protection.** A. M. WEBB. **New Construction Possibilities in Glass-Enameled Tubing.** S. J. CROOKER. A process for vitreous-enameling surfaces of economizer tubes in long lengths has been developed. **Resistant Woods Satisfy Most Corrosion Requirements.** Anon. **Plastics Play Promising Part in Equipping Modern Plant.** Anon. **Pure Iron in a Coke Plant.** Anon. **What Can We use?** W. R. HUEY. The author discusses the materials that may be used for handling various chemicals. **Metals and Alloys With Resistance to Sulphates and Sulphuric Acid.** P. D. SCHENCK. The various materials resistant to the corrosive effects of various strengths of sulphuric acid and sulphates are discussed. Few, if any, commercially available metals or alloys are satisfactory for all concentrations. **Slushing Oils for Corrosion Resistance.** Anon.—JOHN R. BAYLIS.

**On the Effect of Potassium Permanganate in Eliminating Iron from Drinking Water.** C. P. Mom and O. H. Vander Hout. Reprint from the Mededeelingen van den Dienst der Volksgezondheid in Ned.-Indie, 1928. An account of the experiments in eliminating iron from the well water at Tangerang by the use of potassium permanganate. Originally the water was colorless, clear and free from oxygen, but when brought into contact with the air soon became turbid and ferrihydroxide began to settle. Aëration followed by double filtration did not completely remove the iron, the filter effluent showing 0.3 to 1.0 mg. per l. of iron. The experiments indicate the significance of the contact substances, and the need for judicious application of potassium permanganate in cases where the chemical composition of the water is unfavorable or where there is insufficient action of the contact body resulting in incomplete iron removal. Potassium permanganate in a quantity equivalent to the ferro to be oxidized, can completely oxidize the latter and coagulate the ferrihydroxide produced. Other oxydation-agents such as chlorine and hydrogen peroxid do not have the latter effect.—*A. W. Blohm.*

**The Failure of Steam Boilers Due to Cracking.** S. B. Applebaum. Paper read at the Convention in Detroit of the Board of Boiler Rules of the Department of Labor, State of Michigan, January 21, 1929. It is the purpose of this paper to show how the investigation of some cases of cracked boilers points the way along which engineering progress should be made in the modification of design, fabricating methods and operation of boilers to prevent their cracking. The writer discusses bending stresses, temperature stresses and fatigue as responsible for boiler failures rather than the condition of the feedwater. Two things are necessary to prevent boiler failures of the type under discussion: First, to prevent stresses exceeding the elastic limit and second, to make the seams tight from the beginning. All additional stresses, not considered in the design calculation, must be kept within reasonable bounds so that the factor of safety can take care of them. That this is entirely possible is proven by the fact that failures are confined to certain localities in the boiler and that the majority of seams do stand up where the stresses are undoubtedly kept within such bounds.—*A. W. Blohm.*

**Cell Wall and Gram Reaction.** Victor Burke and Mildred W. Barnes. J. Bact., 18: 69–92, 1929. Protoplasm outside of the bacterial cell wall is Gram-negative. A Gram-positive cell can be made Gram-negative by breaking the cell wall. Normal differences in pH or isoelectric point of the protoplasm do not account for differences in Gram reaction. Adding water to the decolorizer will change a Gram-positive cell to Gram-negative. Acid treatment causes Gram-positive cells to become Gram-negative; subsequent alkali treatment will cause these cells to become Gram-positive, if the cell wall is not broken. The function of the iodine mordant in the Gram technique is that of a precipitating agent; the precipitate must be insoluble in water and soluble in the decolorizer. Any factor that alters the cell wall or the dye-iodine-precipitate may affect the Gram reaction. The protoplasm of the cell wall takes no part in the Gram reaction. Bacteria are Gram-positive, Gram-negative, or Gram-variable depending on the permeability of the cell wall.

[In the opinion of the ABSTRACTOR this experiment does not invalidate the Gram method of staining.]—*Edw. S. Hopkins.*

**A Rapid Method For Obtaining The Voges-Proskauer Reaction.** ROBERT H. BEDFORD. J. Bact., 18: 93–94, 1929. The VOGES-PROSKAUER reaction is dependent on the oxidation of acetyl-methyl-carbinol. The reaction can therefore be increased by the addition of a mild oxidizing agent, sodium peroxide being used in this experiment and the color occurring in two minutes. This procedure tends to increase the value of the VOGES-PROSKAUER reaction and makes it more dependable than when carried out according to "Standard Methods of Water Analysis."—*Edw. S. Hopkins.*

**Zeolite-Deconcentrator Combination for Boiler Water Purification.** E. W. SCARRITT. Ind. Eng. Chem., 21: 821–3, 1929. A method of overcoming excessive blow down due to alkalinity concentration of zeolite-softened water is given. Instead of frequent blow down and consequent make up with softened water, the accumulated high sodium alkalinity of boiler water is utilized to treat a pre-determined charge of raw water to be used for make up. Precipitated calcium and magnesium compounds occurring in boilers are removed without interfering with boiler operation by circulating approximately 50 percent of the water in boiler through outside settling tank, the latter being blown independently of boiler operations. Under this plan, 200 days operation showed reductions of 80 percent of zeolite softening and 78 percent of blow off. Method also assures proper sulfate-alkalinity ratio without further chemical treatment.—*Edw. S. Hopkins (Courtesy Chem. Abst.).*

**Some Examples and Precepts of Water Conditioning.** R. E. HALL. Ind. Eng. Chem., 21: 824–9, 1929. Analyses of various typical waters are given and a method of calculating the treatment for given operating conditions is shown, stress being laid on the advantage in use of "equivalent" p.p.m. Ammonia in steam from sewage-contaminated water is discussed and its elimination by pre-treatment of raw water by chlorination is recommended. Several typical scale analyses are given and operating conditions producing these are discussed. Dealing with foaming water, results obtained when using an antifoam of unsaturated hydrocarbon type are given.—*Edw. S. Hopkins (Courtest Chem. Abst.).*

**Improved Equipment for Treatment of Feed Water for Modern Steam Boilers.** J. D. YODER. Ind. Eng. Chem., 21: 829–34, 1929. Modern high pressure boiler practice demands particular attention to feed water quality. For moderately high pressure, below 250 to 300 pounds per square inch, the hot process, lime-soda softener is suitable for average waters. A typical such plant is given, featuring a chemical proportioner for addition of sodium sulfate to maintain sulfate ratio. For higher pressures, in addition to lime-soda treatment, phosphate is substituted for sulfate and followed by filtration and deaëration. Plan of process is shown. Acid-proportioning apparatus to be used with zeolite-softened water is suggested and a plan presented including also continuous blowoff equipment.—*Edw. S. Hopkins (Courtesy Chem. Abst.).*

**A Theory of Liquid Film Formation.** C. W. Foulk. Ind. Eng. Chem., 21: 815–7, 1929. A theoretical discussion of the phenomena of foaming of liquids in general and of the non-foaming of pure liquid is a preface to the article. Liquid films are always produced by the approach to each other, usually with an extension of area, of two previously formed liquid surfaces. An experiment presented illustrates the difference between a pure liquid and a solution. If bubbles are made to issue from two small orifices close together under surface of a liquid, then, in the case of pure liquid, there being no opposing force, these bubbles will coalesce, while, in a solution, an opposing force exists and bubbles will not coalesce.—*Edw. S. Hopkins* (*Courtesy Chem. Abst.*).

**Laboratory Experiments with a Foaming Boiler Water.** A. S. Behrman. Ind. Eng. Chem., 21: 817–8, 1929. Excessive foaming of boiler water previously softened by zeolite process and filtered led to examination of the blow down. Analysis showed high alkalinity and color (from organic matter) as probable cause. Series of experiments showed that reduction of alkalinity, coagulation and filtration, or oxidation, greatly reduced foaming in order given. From this, it is thought that high colloidal organic matter was chief factor in the trouble. Tabulation of results is given.—*Edw. S. Hopkins.* (*Courtesy Chem. Abst.*).

**Chemical Proportioning of Internal Feed Water Treatment.** E. M. Partridge. Ind. Eng. Chem., 21: 819–21, 1929. Stress is laid on the importance of internal treatment of most hard waters with a minimum charge of alkali tannate or similar organic compound. Analyses of scale formed with and without such treatment show that characteristics and composition differ materially. Large reduction of sulfates and corresponding increase of carbonates result from treatment and the scale is soft and easily blown down. Methods of practical application, cost data, and resultant savings are given. —*Edw. S. Hopkins* (*Courtesy Chem. Abst.*).

**Mechanism for the Formation of Calcium Sulfate Boiler Scale.** E. P. Partridge and A. H. White. Ind. Eng. Chem., 21: 834–8, 1929. By actual observation through the microscope the progress of deposition of scale crystals was observed and photographed. The apparatus consisted of a small internally heated metal cell having a polished face and submerged in water with varying concentrations of calcium sulfate and calcium carbonate. A glass port in the wall of the outer vessel permitted observation of changes on polished surface. The bubble theory is suggested to account for the phenomena of boiler scale formation. Scales formed during experiments were typical of those formed during actual boiler operation.—*Edw. S. Hopkins* (*Courtesy Chem. Abst.*).

**Thermal Effects of Boiler Scale.** E. P. Partridge and A. H. White. Ind. Eng. Chem., 21: 839–44, 1929. A study was made to determine effect of scale on rate of heat transfer. An experimental boiler was equipped with thermocouple and runs made with definite quantity of calcium sulfate in solution and a complete log kept of input and output, as well as of temperature differences

between surface and interior of liquid. Runs were made at from atmospheric pressure up to 150 pounds per square inch. These data made possible the calculation of the heat conductivity of calcium sulfate scale, comparison being made with existing data.—*Edw. S. Hopkins* (*Courtesy Chem. Abst.*).

**Effect on Concrete of Acid Water from Stored Bituminous Coal.** E. F. WOLFE. Ind. Eng. Chem., 21: 908–9, 1929. A series of tests made on seepage water showed total acidity ranging from 0.5 to 5.64 percent of sulfuric acid, depending upon previous rainfall (method; 0.5 to 1.0 gm., diluted to 300 cc., titrated boiling with N/20 NaOH, using phenolphthalein indicator). Test for corrosion rates using this water with 4.16 percent acidity were made on seasoned concrete block of 1:2:4 mix. These showed a greater total corrosion in first 7-day period than in 284 days following. A micro-photograph of section of block showed that penetration did not exceed 0.76 mm.; its extent was clearly indicated by reddish iron stains. Wall exposed for similar period showed some characteristics. Test showed that limestone would not remove the acidity of infiltered water as neutralization was interfered with by calcium and iron deposits. Conclusion is that no serious corrosion is probable as long as protective film from dense concrete is not disturbed.—*Edw. S. Hopkins* (*Courtesy Chem. Absts.*).

**Effect of Nitrate Oxygen Upon Tannery Effluent.** E. R. THEIS and J. A. LUTZ. Ind. Eng. Chem., 21: 763–66, 1929. The oxygen demand of tannery effluent is very high. Counts for typical soak water will show 300 million bacteria per cc. Studies were made of reduction of nitrate added in varying amounts and the following facts obtained: large quantities of nitrogen are liberated by bacterial reduction, the rate depending upon incubation period and dose; during early stage of reaction considerable carbon dioxide is liberated, showing that the organic matter breaks down readily, and later, sulfur compounds are oxidized; large dosage of nitrate tends to delay action at first; small dosage may result in incomplete satisfaction of oxygen demand and production of objectionable odors. The amount and composition of gas evolved, the rate of reduction, and the gas pressure resulting were determined. Tables of results and graphs are given.—*Edw. S. Hopkins* (*Courtesy Chem. Abst.*).

**The Relation between the Distribution of Goitre and the Iodine Content of Water in Finland.** ADLERCREUTZ, E. Acta. Med. Scandinavica, 5: 69, 1–45; 187–222; 325–91, 1928. In the absence of reliable statistics as to goitre distribution in Finland, the author relied on information obtained from health officers and private practitioners by means of circularization. In the northern parts of the country, Lapland, goitre was almost absent, while in certain southern and midland areas it was common. In the areas in which goitre was found to be common, there were also a number of inland lakes and rivers; but even here cretinism was rare and there was nowhere an epidemicity corresponding to the type found among the Alps and Himalayas. The writer attempts to correlate the distribution of goitre with the amount of iodine found in the water of the various districts. In some areas where goitre was common, iodine content was low; but this was not always constant and in the north, where goitre is rare, the water contained no more iodine than in the

south. It is concluded that deficiency of iodine is not the only cause of goitre in Finland, although it may be contributory.—*Arthur P. Miller.*

**Endemic Goiter and Its Relation to Iodine Content of Food.** James A. Hayne, Amer. Jour. Public Health, 19: 10, 1111–1118, October, 1929. Article deals with the incidence of goitre in South Carolina and the iodine content of various South Carolina vegetables. A tabulation is also given of the iodine content of the water of a number of South Carolina wells, springs, streams, and public water supplies. The iodine content of South Carolina vegetables did not vary relatively to the distance of the points where the vegetables were grown from the sea coast, as was expected; but natural iodine content of the soils in the various localities was the controlling element. Thus, vegetables grown in the Appalachian Mountain region had a higher iodine content than those grown near the sea coast, except in the immediate vicinity of the sea. The moderate prevalence of goitre in South Carolina is due to the fact that many citizens of that state consume canned vegetables from other localities where iodine content is deficient rather than those locally grown. As data upon iodine content of natural waters are limited, these are given below:

*Iodine in South Carolina Wells, Springs, Streams, and City Water*

| *Date 1928* | *Type of Water* | *Location* | *Iodine, parts per billion* |
|---|---|---|---|
| 2–13 | Seneca River | Clemson College | 1.86 |
| 4–17 | Enoree River | Greenville County | 5.54 |
| 4–17 | Saluda River | Greenville County | 2.08 |
| 5–8 | Broad River | Union County | 6.53 |
| 5–15 | Edisto River | Orangeburg | 3.15 |
| 5–26 | Big Pee Dee River | Near Florence | 2.53 |
| 5–26 | Black Creek | Near Florence | 2.52 |
| 4–17 | Georgia's Creek | Near Easley | 2.81 |
| 4–17 | Table Rock | Pickens County | 1.94 |
| 2–23 | Spring | Clemson College | 0.39 |
| 4–17 | Spring-Chick | Greenville County | 2.05 |
| 5–15 | Well (R. N. Brackett) | Clemson College | 4.22 |
| 5–15 | Well (Hotel) | Clemson College | 1.25 |
| 1–19 | Rain Water | Clemson College | 1.93 |
| 2–22 | Drinking Water, raw | Clemson College | 2.41 |
| 2–23 | Drinking Water, pure | Clemson College | 1.75 |
| 5–15 | Drinking Water, raw | Clemson College | 2.20 |
| 5–15 | Drinking Water, pure | Clemson College | 1.10 |
| 5–22 | Drinking Water, raw | Spartanburg City | 5.12 |
| 5–22 | Drinking Water, pure | Spartanburg City | 1.41 |
| 5–28 | Drinking Water, raw | Columbia City | 4.16 |
| 5–28 | Drinking Water, pure | Columbia City | 2.21 |
| 6–8 | Drinking Water, raw | Charleston City | 4.51 |
| 6–8 | Drinking Water, pure | Charleston City | 2.10 |
| 6–12 | Drinking Water, raw | Greenville City | 5.42 |
| 6–12 | Drinking Water, pure | Greenville City | 3.16 |

—*C. R. Cox.*

**Macon Ousts Flat Rates and Develops A-1 Meter Record System.** R. E. FINDLAY. The American City, 41: 4, 88–89, October, 1929. The Board of Water Commissioners of Macon, Ga., realizing that the equitable way of selling water is through use of meters, recently completed metering all services. There had previously been 8000 meters in use and about 4000 flat rate services. When this metering plan was instigated, a special bookkeeping and card index system was formulated; the article illustrates many of the special record cards. The metering campaign has resulted in a pumpage decrease of about one-third. —*C. R. Cox.*

**Ways and Means for Testing Large Meters.** R. E. FERGUSON. The American City, 41: 4, 96–97, October, 1929. The Assistant Superintendent of the Hersey Manufacturing Company details the Company's experience in the testing of large meters. The article and accompanying illustrations present information not frequently obtainable in current literature.—*C. R. Cox.*

**A Survey of Water-Meter Rates in the United States. Part IV.** The American City, 41: 4, 125–129, October, 1929. This is Part IV of the record of the survey of water meter rates conducted by The Municipal Index and tabulated by The American City from the original statistics. Parts I, II, and III were published in the July, August, and September, 1929, issues, respectively, of The American City.—*C. R. Cox.*

**Steam Turbines in British Pumping.** F. JOHNSTONE-TAYLOR. Water Works Eng., 82: 21; 1465, October 9, 1929. Rand Water Board uses steam-turbine-driven centrifugal pumps. The eight-stage impulse turbine of 28-inch diameter, using steam at 200 pounds pressure and 550° superheat, with 28-inch vacuum developes 920 b.h.p. at 5000 r.p.m.; the duty being 4160 g.p.m. against a head of 565 feet. The multistage impulse turbines are usually built with a velocity stage with two rows of moving blades in front of the single stages. Advantages of low pressure in temperature admits of simple packing glands and greater efficiency. Condensers used are very efficient. London Metropolitan Board uses a 10-stage impulse turbine and a 1000-h.p. triple expansion engine. Steam consumption of the former is 13.9 pounds per pump h.p.-hour, while for the latter it is 10.85 pounds.—*Lewis V. Carpenter.*

**Must the Lowest Bid be Accepted?** LEO T. PARKER. Water Works Eng., 82: 17, 1047, August 14, 1929. The writer cites a number of cases where the lowest bid was unbalanced and the court held that it is not necessary to have a balanced bid provided that the contractor is able to properly prosecute the work and that the bid was submitted by the contractor without fraudulent intent. Bids must always comply with ordinance and advertisements.—*Lewis V. Carpenter.*

**Can a City Buy Land Outside its Limits?** LEO T. PARKER. Water Works Eng., 82: 15, 1025, July 17, 1929. Court decision says: "taking into consideration the fact that the great cities of the state and nation are establishing such plants of such magnitude as to make it impracticable, and, in many instances

impossible, to locate them within the city limits, and especially so in consequence of the topographical requirements of such projects, it is difficult to suggest a valid reason for limiting the city's power in this respect by its boundaries." The author cites several cases where the court permits increase in rates even when a contract has been made for water at a lower rate.—*Lewis V. Carpenter*.

**Elevated Tank Makes Great Saving.** C. F. LAMBERT. Water Works Eng., 82: 15, 1021, July 17, 1929. Study of the distribution system showed that all water was being pumped to a total height of 220 feet to accomodate only 5 percent of the consumers. The railroad uses approximately one half the total supply. By installing a separate pump to handle the railroad supply and a second to serve the high point in the town, the electric consumption was reduced from 2.43 to 1.97 k.w.h. per 1000 gallons. The improvements cost $17,382.03 and the saving, after making allowance for interest and depreciation is more than $6000 per year.—*Lewis V. Carpenter*.

**Reconstructing a Pumping Station to Handle Enlarged Filter Plant.** HARRY F. HUY. Water Works Eng., 82: 21, 1467, October 9, 1929. Western New York Water Co. at Buffalo, N. Y., supplies 120,000 people. Water is taken from Lake Erie; total pumping head is 540 feet. The chief troubles encountered have been tastes and odors, mostly phenolic; many complaints of enteric disturbances; and algae interference during months of April and May. Sedimentation basin is 235 feet long, 110 feet wide, and 16 feet deep, constructed on Raymond concrete piles. Filters consist of 16 units 17 feet 6 inches x 20 feet. Sand used has effective size of 0.5 to 0.6 mm. and uniformity coefficient of 1.35. Filter runs are 36 to 48 hours except during months when algae are prevalent. The 750,000-gallon clear well is located beneath the filters. Alum is used at rate of 70 pounds per million gallons. Alkalinity of raw water is 85 to 95 p.p.m. Copper sulfate, when needed during algae trouble periods, is added through the suction of low lift pumps. Permanganate of potash added in raw water at rate of 0.2 to 0.5 pound per million gallons eliminated all chlorophenol tastes.—*Lewis V. Carpenter*.

## NEW BOOKS

**The Water Engineer's Pocket Book and Directory—1929.** Published by Water and Water Engineering, London, England. The aim of the publishers in presenting this volume was to bring together in one book data and formulae which are of everyday use to the waterworks official. They have not only attained that aim but have produced it in a book which can readily be carried in the pocket without any inconvenience. The book contains: Model water laws; hydraulic data and formulae; information on pumps and pumping; a comprehensive guide to the water undertakings of Great Britain and Ireland; alphabetical list of engineers and their official connections; waterworks statistics; water rates for special purposes; prices for waterworks and material, and personnel of institutions and government departments. The section on hydrau-

lic data and formulae is divided into the following sections: General information; rainfall; compensation and storage; aqueducts, pipes and distribution and purification of water.—*A. W. Blohm.*

**Water Supply Engineering.** Harold E. Babbitt and James J. Doland. McGraw-Hill Book Company, Inc., 1929, 776 pp. Price $6.00. This volume fulfills to a surprising degree the intent of the authors to prepare a comprehensive text for use in civil engineering courses. So well has this been accomplished that the book should have a much wider use than in the colleges alone. It is replete with careful, but brief, discussion of problems of a practical nature and with many unusually useful tables and graphs. It is especially gratifying to note the careful attention paid by the authors to matters of cost and they include a much needed chapter on finances—a subject on which most college students are unusually barren. The book shows evidence of having been adjusted to the requirements of some years of teaching the subject, as one may gather, for example, from the clarity of treatment of the analysis of sand and of the mass diagram method of calculating reservoir storage. The volume includes discussions on hydraulics, water consumption, ground water, dams and impounding reservoirs, intakes and aqueducts, power and pumping, materials, pipes and fittings, design and construction of distribution systems, water supply quality and treatment. The table of contents is very complete, the appendices are helpful, the index is good, the typography excellent and there are surprisingly few errors in type. The authors should be congratulated on their temerity to undertake and their success in accomplishing a difficult task of book writing.—*Abel Wolman.*